FARES STRUCTURE ANALYSIS

DEMONSTRATION STUDY

Requisition No. G50302A

UMTA GRANT IL-08-0081

UWP #4325.34

Submitted to:

Chicago Transit Authority

Chicago, Illinois

Submitted by:

LTI CONSULTANTS, INC.

ERWIN A. FRANCE & ASSOCIATES

SURVEY REPORT

7

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16. Abstract

This study was concerned with the evaluation of alternative fare structures which were formulated as alternatives to the existing flat fare charged for CTA bus and rail services. This evaluation required the costs and ridership changes associated with each fare structure to be estimated. Ridership changes were estimated on the basis of a demand model which was formulated based on existing market data and fares elasticities derived from Stated Preference surveys of CTA users and non-users. Costs of each option were estimated with the assistance of CTA staff. The evaluation was carried out within a framework which allowed a range of CTA fares policy and goals to be taken into account.

This report is contained in two volumes: Volume I describes the work carried out during the course of the whole study. Volume II is concerned only with the the Stated Preference survey work and includes a description of the planning, design, implementation and analysis of the survey data.

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SURVEY REPORT

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EXECUTIVE SUMMARY

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This report is the culmination of the Fares Structure Analysis Demonstration Study carried out by LTI Consultants, Inc., in association with E.A. France and Associates for the Chicago Transit Authority.

- o The project was funded by a grant from the Urban Mass Transportation Administration.

- o The report provides a description of the study work and the conclusions reached.

- o The report is presented in two volumes as follows:

    1. VOLUME I - OPTION EVALUATION

    2. VOLUME II - SURVEY REPORT

Each volume is intended to be free-standing and able to be read independently of its companion volume.

- o Volume I provides a description of the whole study process - the aims, approach, results and conclusions.

- o Volume II provides a detailed description of the survey work - its aims, method and data analysis.

This Executive Summary covers each volume separately; Sections I to X in Volume I and Sections I to VI of Volume II.

VOLUME I

I. BACKGROUND AND INTRODUCTION

The study extended over thirteen months starting in January, 1987. There were three main phases of work:

- Study inception and method formulation;
- Data collection and analysis; option development and costing; formulation of evaluation framework
- Option evaluation and conclusions.

II. STUDY AIMS AND TERMS OF REFERENCE

The aim of the study was to formulate and evaluate a range of medium to long term fare structures which could be implemented by the CTA.

- The method required the establishment of a framework within which options could be evaluated against a range of criteria.

III. AIMS OF THE CTA FARE POLICY

Discussions were held with staff and board members to explore the fare policy goals being pursued by the CTA.

- Areas in which these goals conflict were identified and how the necessary strategic trade-offs between goals could be made were established.

IV. DEVELOPMENT OF EVALUATION FRAMEWORK

The aims of the CTA's fares policy were summarized under ten criteria which were included within an evaluation framework.

- o This allows the priorities assigned by key decision-makers to each criterion to be varied to demonstrate the effect on relative option value.

V. DEFINITION AND ANALYSIS OF CTA'S MARKETS

The market for CTA's services was quantified in terms of size and competitive position against alternative modes of transport.

- o Market segments were determined and levels of sensitivity to fare change established.
- o The segments adopted were:
  - Work versus non-work,
  - Central Area versus Non-Central Area, and
  - Distance.

VI. OPTION DEVELOPMENT

Six options were formulated to represent different methods of charging fares.

- o The options were based on the market segments identified and practical methods of charging fares.
- o The options were:
  1. Peak/off-peak fares

  2(a) Rail zonal fares

  2(b) System zonal fares

  2(c) Rail graduated fares

3. Bus/rail differential fares

4. Maximum prepayment.

These options were designed to address each fare payment method separately; they were not necessarily fully developed in terms of optimizing goal achievement.

VII. OPTION COSTING

Each option was costed in terms of the necessary capital investment for fare equipment and the operating and maintenance costs.

- Costs were based on the necessary changes from the existing system.

- Cost estimates were developed to a level of reliability consistent with the fare revenue estimates.

  - Those options worthy of further development were identified.

- The cost estimates show that the distance-based options would cost considerably more than the others evaluated.

  - The operating and annualized capital cost of distance-based options ranged between $5.8 and $8.6 million per year.

  - The operating and annualized capital cost of the other options ranged between $0.08 and $1.3 million per year.

VIII. DATA SOURCES

A demand model was formulated to estimate the ridership and revenue effects of each option, based on existing data and new data collected through stated preference surveys carried out by E.A. France and Associates.

- Existing data sources - the 1980 Census, 1979 Origin-destination Survey and 1986 CTA ridership data were used to quantify the market segments.

- Potential responses to fare change were estimated using stated preference survey techniques for both CTA riders and other travelers.

- Interviews and self-completion mail back questionnaires were used for data collection.

- Relative values of fare elasticity corresponding to each market segment were derived and compared with values from other sources.

  - Whereas the absolute elasticity values derived appeared high, the relative values between markets were consistent with other sources.

  - Over two miles, distance was found not to influence sensitivity to fare change.

IX. EVALUATION OF OPTIONS

The six options were evaluated within the framework developed.

- Each option was scored according to the extent to which it achieved the aims of the ten criteria.

- A combined score was derived taking account of the level of priority assigned to each criterion.

- A sensitivity analysis was conducted to establish how robust the rank order of option values was to changes in the fare policy priorities.

- The evaluation criteria were:

  - Maximize revenue while minimizing loss of ridership

  - Maximize ridership while maintaining existing net revenue

- Ease of implementation
- Reasonableness (public acceptability)
- Revenue protection
- Cost
- Reversibility (risk)
- Equity of fares
- Simplicity
- Management information

X. CONCLUSIONS

Overall conclusions addressed three distinct issues:

i) Were the aims of the study achieved?

ii) What are the conclusions regarding CTA fares policy?

iii) How valid are Stated Preference techniques in fares policy development?

(1) Achievements

The approach adopted by the study was largely successful in meeting the study aims. In particular:

- o Using both existing data and specific new data collected using Stated Preference surveys, enabled credible values of sensitivity to fare change were derived, at the desired level of dissaggregation;
- o The market segmentation adopted was meaningful in terms of the range of fare structures finally selected for evaluation;
- o A demand model was formulated capable of providing estimates of the effects of the options on ridership and revenue to the desired level of reliability;

- An evaluation framework was established which enabled options to be evaluated in the context of a range of CTA policy goals;

- CTA staff were trained in the use of the evaluation framework and are using it to test complex fare structures that incorporate elements of the options evaluated in this study.

(2) CTA Results

The options which introduced peak/off peak and bus/rail fare differentials ranked considerably higher (Weighted scores of 17-18 in Table E-1) in the evaluation framework than the distance-based options (Weighted scores of 6-9 in Table E-1).

- The high capital costs of the fare equipment necessary for distance based charging could not be justified by additional revenue raised, as this method was no more efficient at raising revenue than the present flat fare system. This is a CTA-specific survey result.

  - It is likely that the complexity of such equipment (read and write on fare media) will also increase maintenance costs.

  - The nature of CTA's rail transit system provides limited scope for staff reductions at stations, despite the higher degree of automation.

  - The scope for reducing annual operating costs to offset the capital costs is not great for CTA.

Prepayment would also achieve many of the aims identified by the study.

- As an alternative to changing the cash fare structure, prepayment would provide a means of introducing those kinds of fare differential found to be worthwhile, at a much lower cost.

- Prepayment also offers considerable potential for exploiting opportunities in the market not easily accommodated by a cash-only fare structure. Through prepayment can be manually validated, relatively simple equipment (read fare media only) can be purchased to automate validation of the prepayment medium.

- The ranking was found to be robust to changes in priority of aims. However, a less conservative choice could be considered in the belief that wider preferences for distance charging would change.

  - Given the good absolute performance of the other options on the important ridership and revenue criteria, it was felt that there is presently no need to risk that change in preference at CTA.

(3) Study Approach

The survey method proved highly successful in meeting the needs of the study by providing disaggregated values of fare elasticity for each market.

- The method was found to be very economical in terms of data collection costs.

- It was very appropriate to this kind of application where no prior experience of rider response exists.

The survey technique has demonstrated that it provides a good method for establishing the relative sensitivity of riders to fare change in different markets.

- This information is vital in the development of fares policies which are effective in fully exploiting opportunities in an increasingly competitive market.

The overall study approach adopted was appropriate to the aims of the project and could be transferable to other urban centers.

- However, the specific results derived for CTA (in terms of ranking of options, etc.) would not necessarily be replicated.

- o Although there are many common elements in the problems of transport in developed urban centers, solutions and remedies tend to be city specific related to:
  - Physical geography
  - Population distribution
  - Existing infrastructure, and
  - Prevailing political and financial climates

Further, the ranking of options was determined by its relationship with the existing fare structure.

- o For CTA, as in many US transit systems, existing fares are very simple; all options would introduce an element of relative complexity.
- o The nature of existing fare structure is, therefore, critical to option evaluation using this approach.

VOLUME II - SURVEY REPORT

I. INTRODUCTION

The aim of the survey work was to derive soundly-estimated travel demand parameters to forecast the sensitivity of different groups of passengers to changes in fare structures.

II. SURVEY METHOD

Following a pilot survey on bus Route 94, two survey methods were adopted based on Stated Preference techniques to include both transit and non-transit travel modes.

- o A self-completion questionnaire distributed at work places concerned with the journey to work.
- o An interview survey conducted at centers of activity concerned with all non-work journeys.

III. METHOD OF ANALYSIS

The stated preference experimental design consisted of five factors for work journeys and three for non-work journeys; both included transit fare as one factor. Both designs adopted eight pair-wise comparisons representing a range of different factor levels.

The analysis of data used four techniques:

- o Analysis of means
- o Linear Strength of Preference
- o Log Odds Analysis
- o Inferred Mode Use Analysis

IV. PLACE OF WORK SURVEY RESULTS

The stated preference design worked reasonably well. Six parameters, i.e., levels of sensitivity, were estimated, of correct sign and of acceptable significance:

- o Transit fare, walk/wait time, travel time difference, gas price, parking cost and time.

However, the levels of sensitivity for fares derived from the survey data produced higher than expected absolute values of fares elasticity, when incorporated in the demand model.

- o It is likely that some respondents were encouraged by the questionnaire to state preferences for options which were not realistically available to them.

- o The relative values of fares elasticity between market segments were credible.

V. ACTIVITY CENTER SURVEY RESULTS

Again, the method yielded parameter values which had the correct sign and reasonable level of significance. Five parameters were estimated for:

- o Transit fare, wait time, walk time, parking time and need to transfer/direct service.

It is likely that some respondents replied as if they had a greater choice of travel mode than in reality.

- o Values of fares elasticity were higher than expected. However, it is very difficult to achieve consensus on what values of Fares Elasticity to expect for non-work travel. This is compounded when there is a complex range of travel choice, such as existed in this survey.

- o Relative values of fares elasticity were credible and generally consistent with the pattern identified for the Place of Work Survey; Non-CBD journeys were found to be more sensitive to fare changes than CBD travel in both surveys.

VI. COMPARISON OF PLACE OF WORK AND ACTIVITY CENTER RESULTS

The two survey methods were compared in terms of their effectiveness in deriving the parameters desired:

- The Place of Work self-completion survey produced significantly lower fare parameter estimates than the Activity Center Survey. This is to be expected; commuters are less sensitive to fare change than leisure travelers.

- The Place of Work Survey produced less efficient estimators than the Activity Center Survey. This is partly because the interview method adopted at Activity Centers allowed a more careful selection of appropriate trade-offs and hence greater precision in experimental design.

- Sensitivity to fare may be over-estimated in the Place of Work Survey because there is an element of self-selection of respondents.

SUMMARY OF OPTION SCORES

CRITERION	WEIGHT	OPT 1 PEAK/ OFF PEAK	OPT 2(a) RAIL ZONAL	OPT 2(b) SYSTEM ZONAL	OPT 2(c) RAIL GRADUATED	OPT 3 BUS/RAIL	OPT 4 PREPAY.	BASE
1. Max revenue, riders const	80	5	3	2	1	5	6	0
2. Max ridership, rev. const	80	5	2	3	1	5	6	0
3. Ease of implementation	20	5	3	1	2	6	4	7
4. Reasonableness	10	1	5	6	5	1	3	0
5. Revenue protection	25	4	2	1	6	4	5	4
6. Cost	80	5	3	1	2	6	4	7
7. Reversibility	20	4	3	2	1	6	5	7
8. Max rides by disadvant.	20	6	3	3	3	5	5	3
9. Simplicity	10	5	3	1	2	6	4	7
10. Management Information	5	3	5	5	6	3	1	0
UNWEIGHTED SCORES:		43	31	27	28	47	43	
WEIGHTED SCORES:		16.8	8.95	8.8	6.1	18.1	17.6	

I. INTRODUCTION

VOLUME II - SURVEY REPORT

I. INTRODUCTION

The aim of the Fares Structure Analysis Demonstration Study was to evaluate alternative fares systems, taking account of their impact on travel demand.

- o A demand model was formulated to estimate the changes in ridership and revenue resulting from the various fare options evaluated.
  - This required soundly-estimated travel demand parameters to forecast the responses of different groups of passengers to alternative fare systems.
- o Travel demand parameters were derived in different ways to ensure that they were appropriate to the particular applications.

  The methods employed were:
  - Time Series Analysis
  - Stated Preference Analysis

This report covers the stated preference analysis.

During the process of validation described later in this volume, various values of fares elasticity are derived based on the survey data. In order to avoid confusion, at this stage it should be pointed out that these values of fares elasticity were not those used in the demand model formulated to evaluate fare structure options described in Volume 1 (referred to later as the Fares Structure Forecasting Model).

As explained in Section III 3.1) and more fully in Appendix B 6.(1), mode share fares elasticity values depend on:

(i) The fares parameter estimated from the Stated Preference Survey data.

(ii) The base probability of using transit.

(iii) The base fare.

The values for fares elasticity derived in this volume of the report are based entirely on the Stated Preference Survey data. The fares parameters, which represent the sensitivity of riders to fare changes, have been derived using a range of different statistical techniques described fully in this volume. The base probability of using transit has been derived by taking the average of the eight preferences given by respondents during the trade-off experiments.

- o This represented the mean preferenced for mode choice given by respondents rather than their actual mode used.

- o The base average fare was purely a function of the questionnaire design, i.e., \$55 per month for the Place of Work Survey and 97.5 cents per journey for the Activity Center Survey. Equation A19 Appendix B shows the formulation used to calculate values of elasticity.

In contrast to this, the demand model described in Volume I used only the fare parameters from the survey work. The base fare was the actual average fare charged by CTA transit services in 1987, i.e., about 83 cents per journey. The base probability of using transit was assumed to be represented by the base market share attracted by transit services. In this way, the demand model derived different fares elasticities for each market.

Stated preference methods aim to derive parameters relating to travel conditions which do not yet prevail.

- o The sample is structured so as to obtain information about well defined sectors of the population for input to market specific forecasting models.

- o Experimental design can be used to reduce bias and estimation error.

- o Professional interviewing and good questionnaire design can obviate many of the problems associated with the hypothetical nature of the subject matter.

1. PRIMARY PARAMETER ESTIMATES.

In the CTA Fares Structure Analysis Demonstration Study the primary parameter estimates provided by the stated preference analysis were average response sensitivities of individuals to changes in transit fare.

These primary parameter estimates were provided in a form so as to enable straightforward input to the Fares Structure Evaluation Model, where with projected price changes these were developed into market segment, made specific elasticities.

2. SECONDARY PARAMETER ESTIMATES.

The secondary parameter estimates provided were average response sensitivities to changes in other model attributes, such as auto gas price, car parking cost and walk time.

3. REASONABLENESS OF SURVEY RESULTS.

Taken together, the parameter estimates allowed a range of tests to be performed to gauge the reasonableness of the survey results. These included:

- Validation of the stated preference parameters by reference to the actual mode of travel

- Computation of elasticities of demand estimated at the mean of the stated preference data sets

- Computation of values of time; for example, the value of transit or car in-vehicle time expressed in terms of transit fare.

The stated preference data was collected for both work and non-work journeys to obtain a broad database of travel demand patterns in the Chicago area.

* * * * *

The following section describes the survey methodology used to collect stated preference data.

II. SURVEY METHOD

II. SURVEY METHOD

Different survey methods were employed to collect stated preference data for journeys to work and non work journeys.

- o The journey to work data was collected through a self completion mail-back questionnaire.
  - These were sent out at selected places of work with a supplementary distribution at parking lots to obtain a greater sample of car users.
- o The non-journey to work data was collected by an interview survey administered at activity centers throughout the Chicago area.
- o The places of work and activity centers were selected to provide sufficient numbers of trips to both central area (CBD) and non central area destinations.
  - This determined the primary level of stratification.
- o During the analysis, responses were further stratified to improve the explanatory power of the models. Secondary strata included:
  - Current travel mode
  - Travel distance
  - Car availability
  - socio-economic profile of the respondents (sex, income, race).
- o Appendix A to this report contains a detailed report of the survey method including specimen questionnaires.

Three pilot studies were undertaken to test the proposed survey methods:

- Route 94
- Place of Work Pilot Study
- Activity Center Pilot Study

1. ROUTE 94

The survey on Route 94 had two aims:

- To establish transport alternatives to aid the design of a trade-off survey for pairwise comparisons
- To assess the feasibility of using self-completion questionnaires and to evaluate the quality of data collected using this technique.

Route 94 was selected because it is a reasonably long route running through a broad range of different neighborhoods. It could therefore provide a good trial of the survey methodology.

The survey was conducted on Monday 13th April 1987. 360 questionnaire cards were distributed and collected.

2. PLACE OF WORK SURVEY

Pilot surveys were conducted on 24th June and 21st July 1987. The pilot survey aimed to test:

- The feasibility of using self-completion trade-off questionnaires for people traveling to work
- Assess the extent to which employers could assist in the distribution and collection of the questionnaires and monitor response rates

A total of 1510 questionnaires were distributed at places of work of which 380 were returned.

The main survey was carried out during the latter part of August and during September. 8500 questionnaires were distributed to 30 employers both within and outside the central area. Just over 1000 questionnaires were returned. These questionnaires were then edited and encoded in preparation for the analysis.

3. ACTIVITY CENTER SURVEY

A trial of approximately 60 interviews was conducted on 25th and 26th June 1987 at Lincoln Park Zoo and Water Tower Place.

The pilot survey aimed to test:

- o The feasibility of the trade-off interview in terms of respondent comprehension and acceptability

Having evaluated the pilot survey findings, modifications were made to the survey design.

The main interview survey was conducted from mid-July to mid-September during which time around 900 interviews were conducted. Interview sheets were then edited and coded prior to data entry in preparation for the analysis stage.

* * * * *

The following Section of this Survey report describes the methods of analysis of the stated preference techniques.

The main survey was [illegible] out during the latter part of August and during September. [illegible] questionnaires were distrib- uted [illegible] Just over [illegible] questionnaires were [illegible]. These question- naires [illegible] analysis.

3. ACTIVITY CENTER SURVEY

A [illegible] 25th and [illegible] Plaza.

The [illegible]

[illegible]

Recall [illegible] were made [illegible]

The [illegible] mid-September [illegible] were conducted [illegible] data [illegible]

The [illegible] methods [illegible]

III. METHODS OF ANALYSIS

III. METHODS OF ANALYSIS

Stated Preference techniques have gained favor through their ability to assess the demand effects of policy variables regarded as difficult and sometimes impossible to quantify, by analyzing observed travel behavior.

- o Stated Preference techniques also permit disaggregation of response to a much greater extent than is typically allowed by observed travel data (eg ticket receipts).

- o Analysis is usually performed at individual respondent level using disaggregate modeling techniques.

In this study, Stated Preference techniques were selected for two principal reasons:

- o The radical nature of the proposed changes in future fare structures to be evaluated; there was no suitable data relating to Chicago for calibration of parameters by conventional modeling techniques.

- o The need to assess the sensitivity of different market segments (work versus non work trips: CBD versus non CBD destination trips) to the changes in fares structure, thereby allowing any significant differences in sensitivity to be incorporated during evaluation.

1. STATED PREFERENCE EXPERIMENT DESIGN

The core of the questionnaire survey was a Stated Preference experiment which invited the respondent to express his or her preference between transit and alternative travel modes.

Account Name: NORTHWESTERN

Account Number: 50152-000

WATCH : DATA ENTRY TYPOS, ~~AND NOT TAPING A COPY OF~~ THEIR PINK TICKET TO THE BACK OF OUR "BINDING COPY B/TICKET" IN THE BOOK.

D/O: 3/7

Reason: Watch Acct.

Dept. 062 ~~0062~~//

1-399			400-599			600-799		
Job #	Prod.	Quan.	Job #	Prod.	Quan.	Job #	Prod.	Quan.
PXU293	14	99	PXU594	21	3			
PXU312	14	68	PXU400	21	24			
PXU314	14	44	PXU402	21	4			
PXU320	14	33	XUP408	21	12			
PXU330	14	1	PXU410	21	11			
PXU337	14	1	PXU412	21	4			
			PXU413	21	2			
			PXU414	21	4			
			PXU415	21	1			
			PXU425	21	17			

(1) Question type - Pairwise comparisons

Pairwise comparison type State Preference questions were asked:

- o Respondents were asked to state their preference for traveling to work by car or transit if for example, the following factors described the two travel modes:

Figure 3.1

EXAMPLE OF CHOICE IN SURVEY QUESTIONNAIRE

OPTION	COST	TIME
TRANSIT	Fare per Month Was $70.00	Transit journey 10 minutes longer than by car
CAR	Gallon of Gas Was $1.80	9 minutes were spent parking and walking to the office

Assuming the respondent stated a preference for car, all that could be inferred was that the description of the car factors were preferred to all the transit attributes.

- It would be impossible to say whether it was solely because of the high level of transit fare.

By asking a series of such questions - referred to as pairwise comparisons - it is possible to determine the sensitivity or importance attached to each travel mode factor.

- Often however, the series of questions is insufficient to establish with any degree of precision the importance or sensitivity attached by a given individual to all five factors.

- This may be because the number of questions is insufficient or that the range in level taken by each factor is not large enough to cause changes in response.

However, by analyzing the stated preference of all respondents together, (while retaining estimation at the individual observation level), it is possible to derive average sensitivities for specific market segments.

(2) **Passenger Preference Estimation**

To increase the precision in estimating passenger preferences, responses were measured on a scale. For each question, respondents were asked to indicate their strength of preference by saying whether they

- o Strongly preferred A or B,
- o Weakly preferred A or B
- o Were indifferent between A and B.

Where A and B were the choice of mode, transit versus alternative.

This aided calibration by regression, with a clearly defined error structure built into the explanation of passenger preference.

- o This in turn allowed the application of statistical tests on the parameter estimates.
    - A more detailed description of the modeling technique is provided in Appendix B to this Survey Report.

In this study, a series of eight preference questions was asked. These were shown pictorially to aid comprehension. A copy of both the Place of Work and Activity Center questionnaire pictographs are shown in Appendix A.

- o The pilot studies found this sufficient to estimate the transit fare parameter with precision.

(3) **Stated Preference Experiments**

Care was taken in determining the levels taken by each factor in each of the eight pairwise comparisons.

- This process, known as constructing an 'experimental design' enabled the effects of each factor to be isolated (e.g. the effect of transit fare to be isolated from transit walk/wait time).

- To achieve this, the experimental design was constructed to be orthogonal; each factor was unrelated (uncorrelated) to any other factor.

Although the methodology was fundamentally the same in both the Place of Work and Activity Center Surveys, features were introduced into the Activity Center Survey to tailor the Stated Preference experiment to the specific market.

(4) Place of Work Experiment

The Place of Work experiment had eight pairwise comparisons of car versus transit. Each comparison was described by five factors.

Factor 1	Transit Fare
Factor 2	Transit Walk
Factor 3	Travel time difference
Factor 4	Gas cost
Factor 5	Car Parking Cost/Walk Time

- The key factor of interest - Transit Fare - was set at four levels ($40.00, $50.00, $60.00 and $70.00).

- The other four factors took two levels.

  - The factors with levels taken are shown in Fig. 3.2 following this page.

  - The car parking factor differed according to whether the questionnaire was distributed at CBD or non CBD locations:

Figure 3.2

ATTRIBUTE LEVELS FOR PLACE OF WORK SURVEY QUESTIONNAIRE

FACTOR	UNITS	LEVELS
Transit Fare	$/month	$40 $50 $60 $70
Transit Walk	Minutes per Single Trip	5 minutes 10 minutes
Travel Time Difference	Transit or Car;Single Trip	5 minutes 10 minutes
Gas Cost	$ per Gallon	$1 $1.80
Car Park Cost (CBD only)	$ per Month	$100 $200
Car Park/ Walk Time (Non CBD)	Minutes per Single Trip	3 minutes 9 minutes

  - For the CBD locations, the factor was expressed in terms of monthly cost;
  - For the non CBD locations, the factor was expressed in terms of parking/walk time.

- This difference was adopted following analysis of the pilot survey.

- Car parking was invariably free outside the CBD.
  - Respondents in these areas were found to be insensitive to the car park charges specified in the pilot survey; cost was therefore replaced with parking time.

- Car parking in the CBD invariably costs money and respondents were found to be reasonably sensitive to changes in charge.

(5) Activity Center Experiment

The Activity Center Survey featured three SP experiments:

- Transit versus car
- Transit versus walk
- Transit versus non travel

A single Stated Preference experiment was conducted by interviewing each respondent. The particular Stated Preference experiment used depended on:

- The actual mode of travel to the activity center. Car users and walkers answered car-transit and walk-transit questionnaires respectively.
  - If the respondent had not used transit during the previous five years, only socio-economic questions were asked.

- The Second Best Alternative' when the actual mode of travel to the activity center was transit.

- CTA service users were asked which alternative they would have chosen if transit had been unavailable. Respondents were asked to select from walk, car and not travel; the appropriate Stated Preference questionnaire was then administered accordingly.

As with the Place of Work Survey, each experimental design comprised eight pairwise comparisons, but only three factors were used to describe each.

- o Transit fare featured in all comparisons.
- o The other attributes depended on the alternatives being compared.

The factors with their levels are shown in Fig 3.3 below.

Figure 3.3

ATTRIBUTE LEVELS FOR ACTIVITY CENTER SURVEY INTERVIEW

FACTOR	LEVELS	CAR OR TRANSIT	WALK OR TRANSIT	NOT TRAVEL OR TRANSIT
Transfer	Direct or indirect	*		*
Fare (cents)	50,90,110 or 140	*	*	*
Park time (minutes)	5 or 10	*		
Wait time (minutes)	5 or 10		*	*
Walk time (minutes)	20 or 40		*	

2. METHODS OF ANALYSIS

The Stated Preference data was analyzed using four methods:

(1) Analysis of Means

(2) Linear Strength of Preference Analysis (STP)

(3) Log Odds Analysis; and (LO)

(4) Inferred Mode Use Analysis (IMU)

A brief description of each of the methods is provided here. A more detailed description is provided in Appendix B to this report.

(1) Analysis of Means

The Analysis of Means provides a descriptive presentation of the data. It is an aggregate measure averaging the individual responses by the level taken by each factor.

- o Tabular and graphical presentation of the results is provided in Sections IV and V.
- o The conversions allowed responses to be compared inter personally and intra personally.

(2) The Linear Strength of Preference Analysis

Assumes an equal interval between the five measure points.

(3) The Log Odds Analysis

Converts the strength of preference into a measure of probability of using a travel mode.

(4) The Inferred Mode Use Analysis

Converts the strength of preference into a measure of travel mode use: a value of one implying use of transit, a value of zero implying use of car.

- o Rather than discarding indifferent responses or assigning these to the current mode, a weighting procedure was used. (See Appendix B).

(5) The Techniques (2) - (4) Employ Disaggregate Estimation.

Each analyze the data at the level of the individual Stated Preference response and attempt to explain the cross sectional variation by:

- o The variation in attribute levels
- o The socio-economic characteristics of the respondent
- o Journey characteristics of the respondent.

The methods differ in terms of:

- o The conversion of the strength of preference response categories;
- o The functional form of the relationship between the response measure and the attribute levels; and
- o The estimation technique

(6) Conversion of the Strength of Preference Response Categories

In answering the Stated Preference questions, respondents were requested to indicate their strength of preference on a scale of one to five. Various conversions could be made to allow the response to be modeled quantitatively.

- o Three alternatives were investigated; they are set out as shown in Figure 3.4 below using the car/transit comparison as an example:

Figure 3.4

ALTERNATIVE CONVERSIONS APPLIED TO STRENGTH OF PREFERENCE

STATED PREFERENCE	Linear strength of preference	Probability of using transit	Inferred mode use
Strongly prefer transit	5	0.9	1
Weakly prefer transit	4	0.7	1
Indifferent	3	0.5	-
Weakly prefer car	2	0.3	0
Strongly prefer car	1	0.1	0

(7) Functional Form of Relationship

The model forms are presented in Appendix B.

- o The Linear Strength of Preference Analysis estimated a linear relationship between the factors in the design and the strength of preference measure.

- o The Log Odds and Inferred Mode Use Analyses assumed a logistic relationship between the converted strength of preference measures and the factors in the design.

(8) Estimation Techniques

Ordinary Least Squares regression could be used to estimate the Strength of Preference analysis parameters.

- o Similarly, the Log Odds Analysis estimation equation could be transformed to enable Ordinary Least Squares regression.

- o Ordinary Least Squares could not be used in the Inferred Mode Use Analysis because of the nature of the dependent variable. Instead, maximum likelihood estimation was used. This technique attempts to find those parameter estimates which are most likely to have led to the inferred mode used.

An analysis of the Activity Center Survey data was also performed on:

- o The proportion of respondents who had never traveled by CTA

- o The second best alternative of transit users which determined the Stated Preference experiment which they completed.

Maximum likelihood estimation was used to explain the observed 'choice probabilities'.

- o Socio-economic and journey characteristics were input to explain the variation in choice probability across respondents.

- The resultant prediction equations may be used in conjunction with the Stated Preference parameters to predict more accurately the patronage response to transit fare changes.

(9) Market Segmentation

Basic models were estimated on the total data sets. These models assumed that common parameter values apply to all respondents. This is a strong assumption; it may be relaxed by market segmentation.

- o For the Activity Center Survey the responses to the three analyzed experimental designs could be analyzed either:
- o Individually, using binary models (ie the same models in the Place of Work analysis) or,
- o Together, using a 'multinomial' model.
  - A description of the multinomial model and its estimation is provided in Appendix B.
- o Appendix B details:
  - Theoretical and forecasting merits of the binary and multinomial models
  - The treatment of suppression/generation
  - Estimation of market segment specific parameters where the same parameter value is assumed to apply to all respondents in a market segment.
  - The alternative ways segmentation may be achieved during estimation and the rationale for the adopted method.
  - The statistical tests to determine the significance surrounding any differences between market segment parameter levels.

Market segment parameters were estimated as follows:

TRANSIT - CAR

Experimental Design (Activity Center Survey Only)	:	Transit-Car
	:	Transit-Walk
	:	Transit-Not travel
Current Mode	:	Transit
	:	Car
	:	Walk (Activity Center Survey only)
	:	Not Travel (Second Best Alternative: Activity Center Survey only)
Destination	:	CBD
	:	Non CBD
Distance	:	Under 2 miles
	:	2 - 6 miles
	:	Over 6 miles
Car Availability	:	Available
	:	Unavailable
Sex	:	Male
	:	Female
Household Income	:	Less than $30k per year
	:	Over $30k per year
Race	:	White
	:	Non White

In some models fitted to the Place of Work data, the individual observations were weighted to reflect the transit/car share in each CBD/Non CBD and journey distance market segment. These weights were determined by comparison of the survey and Chicago census journey to work mode shares (see Section IV.).

3. TESTS OF REASONABLENESS

Three tests were applied to the parameters to assess their reasonableness:

- The implied elasticity of demand
- The implied values of time; and
- The ability of the parameters to replicate actual mode choice

This section looks briefly at the derivation and application of each test. Appendix B provides a formal description of each of the parameters.

(1) Implied Elasticities of Demand

The parameters provided by the Log Odds Analysis and Inferred Mode Use Analysis can be translated relatively easily into mode share elasticities by measuring the percentage responsiveness of transit market share to percentage changes in factors, such as transit fare.

- The formulation of the estimated relationship between mode use and the factors describing each mode (eg transit fare) is such that the elasticity value depends on:
  - The size and sign of the estimated parameter
  - The base probability of using transit
  - The base level of the factor
- For transit fare, the estimated parameter should be negative: fewer people should use transit the higher the transit fare, hence the transit market share (all things being equal) should therefore decline.
- The relationship between the base probability and elasticity is negative.

- This implies that the higher the base transit market share the less responsive the remaining non transit users should be to fare changes.

- It becomes increasingly difficult to capture travelers from other modes by lowering the fare.

o The relationship of elasticity and the base level of factors is positive; the higher the transit fare associated with a given base probability (mode share), the higher the elasticity value.

There are several measures of elasticity which have been produced for mode share models of this type. Two commonly used measures are:

o Representative elasticity

o Aggregate point elasticity

- The representative elasticity is the easiest to calculate but ignores the distribution of individual elasticities across the population. It is likely to be biased if the population is heterogeneous.

- The aggregate point elasticity is estimated on the individual responses. In instances when change in a factor (in this case transit fare) is uniform across individuals, the value provided by the aggregate point elasticity becomes a weighted average of the individual elasticities (with weight equal to the base probabilities).

Calculation of elasticities of demand based on the Linear Strength of Preference Analysis requires an additional step to convert the strength of preference into a probability of use measure.

o Although elasticities of demand are provided in Sections IV and V they have not been used in the Fares Structure Forecasting Model, because the elasticity measure is not constant.

- Forecasting has used the Incremental Logit Model - a straightforward reformulation of the logit model.

This model requires data on:

- o Trips by transit
- o Transit mode share
- o The base and forecast transit fare distribution

Having predicted the new transit ridership following a change in fare, an elasticity measure may be calculated based on

- o The percentage change in ridership and,
- o The average percentage change in transit fare.

This is usually referred to as an overall elasticity rather than a mode share elasticity.

- o Elasticity measures of this form are presented in Volume I of this report.

(2) Implied Values of Time

The Stated Preference experiment works on the principle that individuals trade-off one factor against another.

- o In the case of one monetary and one time-based factor, the rate at which individuals trade off provides a value of time.
- o Values of time depend on the nature of both the monetary and time-based attributes.
  - For example, in-vehicle time is normally preferred to out of vehicle time (walk/wait); and car operating costs are often perceived differently to transit fares.

A number of time values could be estimated from the Place of Work and Activity Center data sets. It was decided to evaluate all time factors in terms of transit fare:

a) Place of Work Survey

- Overall travel time (travel time difference factor)
- Travel walk/wait time
- Parking time (Non CBD only)

b) Activity Center Survey

- Park time
- Wait for transit time
- Walk time
- Direct/interchange service

In addition, the relative value of the other monetary factors describing the car journey in the Place of Work Survey were evaluated in terms of transit fare:

- Parking cost
- Gas price

In estimating the values of time on the Place of Work Survey results, the factors required standardization.

o All factors were expressed either in costs or minutes per one way trip. Forty one-way trips were assumed per month.

(3) Replication of Actual Mode Choice

One criticism of Stated Preference based travel demand models is that stated preferences may not accord with preferences as revealed by the actual travel mode used.

o However, validation studies have provided evidence that models based on well conceived Stated Preference experiments accord closely with observed behavior.

Two validation exercises were possible on the data provided by the Place of Work and Activity Center Surveys:

a) Disaggregate

The use of Stated Preference derived utility functions to predict individual travel mode use which can then be compared to actual travel mode use;

b) Aggregate

The use of Stated Preference derived utility functions to predict aggregate mode share by market segments which can then be compared to actual mode share.

Disaggregate validation is the easier, requiring:

- The actual levels of those factors describing chosen and rejected modes

- The socio-economic and other trip characteristics (CBD and non CBD) which affect either the sensitivity to changes in the factors or the unexplained preference for the chosen mode determined by the Stated Preference analysis;

- The appropriate Stated Preference estimated parameters.

Aggregate validation requires the distribution of the actual factor levels in the population.

- In this study, disaggregate performance measures were provided to indicate the ability of the model parameters to produce market share by market segment.

- o The Stated Preference questionnaires were designed to gather data on the perceived levels of factors of both actual and rejected travel modes in which there was interpersonal variation:

a) Place of Work Survey

- Transit fare
- Parking cost (CBD) and parking time (Non CBD)
- Travel times (transit and car)
- Transit wait time

b) Activity Center Survey

- Transit fare
- Parking time
- Transit wait time
- Walk time
- Whether direct or indirect service

There was no need to ask about gas price, given that there was little spatial variation in pump prices across Chicago.

Validation was performed by constructing generalized costs for actual and rejected modes by reference to the perceived levels of the factors and the Stated Preference parameters.

- o Then, these generalized costs (including the unexplained Stated Preference modal preference) were introduced to explain observed and rejected mode choice.

The exercise produced two parameters: a constant and one relating to the generalized cost.

- If the actual and predicted travel modes correspond reasonably closely, the constant and generalized cost validation parameters will not differ significantly from zero and one respectively.

- If actual and predicted choices do not accord, the Stated Preference parameters may be adjusted according to the size and sign of the validation parameters.

* * * * *

The following Section provides an analysis of the Place of Work Survey results which were conducted in the course of the project.

IV. PLACE OF WORK SURVEY RESULTS

IV. PLACE OF WORK SURVEY RESULTS

The Place of Work Survey was designed to provide a comprehensive database from commuting patterns in Chicago.

The total Place of Work sample was 1220 including responses to the pilot surveys conducted in June and July 1987. The main survey was done in late August and early September at 25 locations around the Chicago area.

1. SAMPLE DESCRIPTORS

This section deals with the nature of the sample in the Place of Work Survey as revealed through:

- o The questions on socio-economic status
- o Travel behavior
- o Perceptions

Wherever possible the tables show descriptors, split by travel mode: namely transit (transit wholly or in part) and non transit (car throughout). Just under 80% of the total sample consisted of transit users, with the remainder using private car.

(1) Sex Profile

The split by sex (Figure 4.1.1 following this page) of returned questionnaires was 39% male and 61% female for both the transit and non transit categories.

- o Compared with the 1980 Journey to Work census this suggests an oversampling of females.
  - The 1980 Journey to Work survey indicated a male-female split of 55:45 in Chicago County and 57:43 in Cook County.

Figure 4.1.1

SEX PROFILE OF RESPONDENTS BY TRAVEL MODE

SEX	TRAVEL MODE: Car throughout		TRAVEL MODE: Transit Use		TOTAL	
	Number of Obs	%	Number of Obs	%	Number of Obs	%
Male	92	38.8	349	39.4	441	39.3
Female	145	61.2	537	60.6	682	60.7
Total	237	100.0	886	100.0	1123	100.0

Figure 4.1.2

RACE PROFILE OF RESPONDENTS BY TRAVEL MODE

RACE	TRAVEL MODE: Car throughout		TRAVEL MODE: Transit Use		TOTAL	
	Number of Obs	%	Number of Obs	%	Number of Obs	%
Hispanic	12	5.4%	41	4.8%	53	4.9%
Asian	7	3.1%	35	4.1%	42	3.9%
Black	51	22.8%	268	31.5%	319	29.6%
White	150	67.0%	486	57.0%	636	59.1%
American Ind			6	0.7%	6	0.6%
Other	4	1.8%	16	1.9%	20	1.9%
Total	224	100.0%	852	100.0%	1076	100.0%

The survey is probably biased towards the female population, because

- o Women were more willing to return questionnaires
- o The total sample was heavily weighted towards transit users of which women are typically the majority.

The survey responses probably represent transit users more accurately than they represent commuters in general.

(2) Race Profile

59% of the total sample was white, with 30% black, 5% Hispanic, 4% Asian and 2% other. The survey race Profile is shown in Figure 4.1.2 on the previous page.

- o This profile closely resembles the 1980 Journey to Work results for Chicago in which the splits were 56% White, 31% Black, 13% Hispanic.
  - Cook County showed a much higher proportion of Whites; 73% White, 19% Black, 7% Hispanic.
  - However it is not clear exactly how the smaller minorities were defined or included in the 1980 Journey to Work survey.

There was a higher proportion of white people driving cars than using transit (67% vs 57%), the converse applied for the minorities.

(3) Household Income Profile

Distribution by household income for the sample, is similar to the 1980 Journey to Work sample.

- o Figure 4.1.3 following this page shows approximate income distributions for the study against Chicago and Cook Counties (1980 Journey to Work).

Figure 4.1.3

INCOME DISTRIBUTIONS FOR THE PLACE OF WORK SURVEY AND THE 1980 JOURNEY TO WORK SURVEY

INCOME	PLACE OF WORK SURVEY	CHICAGO COUNTY	COOK COUNTY
<$10,000	5%	12%	9%
$10,000-20,000	19%	27%	22%
$20,000-30,000	22%	25% *	26% *
$30,000-40,000	17%	16% *	19% *
$40,000-50,000	14%	11% *	13% *
>$50,000	22%	19%	12%

- The current study appears to have slightly undersampled lower income people and oversampled the top end of the income range.

- The kinds of workplace where the survey was carried out may have precluded the very lowest end of the income distribution, and may have boosted the higher categories. The study returns may also reflect lower interest and/or literacy at the bottom end.

Figure 4.1.4 on the following page, shows that transit passengers represent more of the poor (<$10,000 pa : 5.6% vs 2.3%) and fewer of the very affluent (>$50,000 pa : 19.5% vs 32.0%) than auto users.

- This is intuitively reasonable.

(4) Household Size Profile (Figure 4.1.5)

Household Size Profile, as shown in Figure 4.1.5 on the following page, showed a reasonable distribution, with an average 2.8 persons per household for the whole Place of Work sample.

- One third of all respondents lived in households of 2.

- The observed differences between the transit and non transit distributions were negligible.

Figure 4.1.4

HOUSEHOLD INCOME PROFILE OF RESPONDENTS BY ARRIVAL MODE

HOUSEHOLD INCOME	TRAVEL MODE: Car throughout # Obs.	Car throughout %	TRAVEL MODE: Transit Use # Obs.	Transit Use %	TOTAL # Obs.	TOTAL %
<$10,000 p.a	5	2.3%	47	5.6%	52	4.9%
$10,000 - 20,000 p.a	30	13.5%	176	20.9%	206	19.4%
$20,000 - 30,000 p.a	40	18.0%	195	23.2%	235	22.1%
$30,000 - 40,000 p.a	44	19.8%	141	16.8%	185	17.4%
$40,000 - 50,000 p.a	32	14.4%	118	14.0%	150	14.1%
>$50,000 p.a	71	32.0%	164	19.5%	235	22.1%
TOTAL:	222	100.0%	841	100.0%	1063	100.0%

Figure 4.1.5

HOUSEHOLD SIZE PROFILE OF RESPONDENTS BY TRAVEL MODE

HOUSEHOLD SIZE	TRAVEL MODE: Car throughout # Obs.	Car throughout %	TRAVEL MODE: Transit Use # Obs.	Transit Use %	TOTAL # Obs.	TOTAL %
One	34	14.2%	162	18.6%	196	17.6%
Two	80	33.5%	292	33.5%	372	33.5%
Three	50	20.9%	163	18.7%	213	19.2%
Four	47	19.7%	138	15.8%	185	16.7%
Five	17	7.1%	58	6.7%	75	6.8%
Six	7	2.9%	40	4.6%	47	4.2%
Over six	4	1.7%	19	2.2%	23	2.1%
TOTAL:	239	100.0%	872	100.0%	1111	100.0%

- o The proportions of households with 2 persons (33.5% in both cases), corresponded exactly.

(5) **Age Profile (Figure 4.1.6)**

The age distributions, as shown in figure 4.1.6 are fairly similar for transit and non transit, with slightly more young people using transit (18-24 category : 16.1% vs 11.8%).

- o This indicates that car ownership is lower for this group.

- o Proportions in the 25-34 age group were virtually the same at 35%, while transit drew fewer (24.3% vs 31.5%) of the 35-44 group.

(6) Car Availability Profile

Figure 4.1.7 compares the distribution of car availability between respondents traveling by car and by transit. This is also compared with data from the 1980 census. Whereas the car journeys are consistent with the census data, it appears that for transit journeys, respondents from zero car households have been under-sampled and respondents from 2 or more car households have been over-sampled. This pattern is similar to that found with the income profile.

It is interesting to note that the census data indicates that 38 percent of CTA riders come from zero car households. This is in contrast with the 65 percent of CTA riders who said they did not have a car available for the journey to work during the 1979 Origin Destination Survey. Obviously, there is a wide disparity between car owndership and car availability.

(7) Summary of Socio-Economic descriptions

The review of the socio-economic aspects of the Place of Work Survey reveal the following:

- o The survey appears to be biased in favor of women (compared with 1980 Journey to Work), but there was no difference between transit and non transit

Figure 4.1.6

AGE PROFILE OF RESPONDENTS BY TRAVEL MODE

AGE	TRAVEL MODE: Car throughout # Obs.	%	TRAVEL MODE: Transit Use # Obs.	%	TOTAL # Obs.	%
12-17			7	0.8%	7	0.6%
18-24	28	11.8%	145	16.1%	173	15.2%
25-34	85	35.7%	318	35.2%	403	35.3%
35-44	75	31.5%	219	24.3%	294	25.8%
45-64	43	18.1%	184	20.4%	227	19.9%
>65	7	2.9%	30	3.3%	37	3.2%
TOTAL:	238	100.0%	903	100.0%	1141	100.0%

Figure 4.1.7

CAR AVAILABILITY BY TRAVEL MODE

ARRIVAL MADE	Number of Cars Available: 0	1	2	3	>3	TOTAL
TRANSIT						
No. of Cars	167	365	254	74	23	883
Percentage	18.9%	41.3%	28.8%	8.4%	1.0%	100.0%
CAR						
No. of Cars	3	86	99	42	8	238
Percentage	1.3%	36.1%	41.6%	17.6%	3.4%	100.0%
TOTAL:						
No. of Cars	170	451	353	116	31	1,121
Percentage	15.2%	40.2%	31.5%	10.3%	2.8%	100.0%

- The race profile accorded to the 1980 Journey to Work survey with minorities totaling more than 40% of the transit sample and about one third of the non transit sample.

- The overall income distribution was well represented in the study survey, with more poor and fewer rich people using transit.

  - Roughly two thirds of transit riders were in the $20,000 - $50,000 pa range.

- The study household sizes is reasonable with a mean of 2.8 persons per household

- Age distribution is reasonable with a trend towards more younger working people on transit.

The next group of subsections discusses some of the travel behavior and perceptions of respondents. Naturally some of the questions were mode specific and the discussion below assumes this when appropriate; auto users did not answer question 4 and transit users ignored question 5.

(8) Distance Traveled

Question 2 asked for an estimate of how far the respondent traveled to work. This was a subjective estimate and therefore would have some degree of error.

- Figure 4.1.8, below, shows the results for all travelers by mode.

Figure 4.1.8

DISTANCE TRAVELLED

PERCEIVED DISTANCE (MILES)	AUTO	TRANSIT
< 2	11%	5%
2 - 6	31%	26%
> 6	58%	69%

- Two thirds of the respondents came from more than 6 miles, a quarter reckoned between 2-6 miles, with only 8% at less than 2 miles.

- Not surprisingly there are fewer very short trips by transit since there are many short journeys which are awkward by public transport.

(9) Transit Fare

Question 4a asked transit users to state their usual monthly fare. Figure 4.1.9, following this page, shows that 84% paid less than $50 with almost half the total paying $41 - $50 per month. Almost three quarters of all travelers paid $31 - $50 per month.

(10) Walk/wait Time

Question 4b asked transit users to estimate their walk and wait time (added together). Figure 4.1.10 following this page, shows that half believed that this totaled no more than 10 minutes.

- This seems very low, but even if some respondents misunderstood the question, the overall perception is that access is good among those who use transit.

  - The table shows that car users answering the purely hypothetical question were remarkably accurate in their responses.

(11) Alternative to Transit

Questions 4c and 4d asked transit users if they could regularly drive or share a ride. Figure 4.1.11 following this page shows their responses.

Figure 4.1.9

TRANSIT FARE PER MONTH

FARE ($ MONTH)	PER CENT
< 21	4%
21 - 30	7%
31 - 40	23%
41 - 50	49%
51 - 60	3%
61 - 70	3%
71 - 80	
81 - 90	3%
91 - 100	
> 100	2%

Figure 4.1.10

WALK AND WAIT TIME FOR TRANSIT TRAVEL

WALK AND WAIT TIME (MINUTES)	TRANSIT USERS	AUTO USERS
< 6	21%	23%
6 - 10	30%	31%
11 - 15	24%	23%
16 - 20	12%	13%
> 20	13%	10%

Figure 4.1.11

TRANSIT ALTERNATIVES

RESPONSE	YES	NO	TOTAL
Could you drive?	52%	48%	100%
Could you share?	26%	74%	100%

- o About half could drive but apparently chose not to, suggesting that transit still has a strong appeal in Chicago.

  - A smaller proportion (26%) claimed they could ride-share but clearly, for them, transit had a stronger appeal.

(12) Parking Times

In question 4f transit users were asked to estimate how long it would take to find a space and park, while in question 5b auto users were asked to estimate parking times from their daily experience. Figure 4.1.12 following this page shows the results:

- o Perceptions of transit users were of longer parking times than the stated experience of auto users.

  - 81% of the latter experience very short parking times while only 9% took more than 10 minutes.

(13) Parking Charges

Questions 4g and 5a asked transit and auto users respectively to estimate parking charges.

- o Naturally auto users based their estimates on regular usage.

  - Figure 4.1.13 shows the results for both.

- o Again transit users appear to over-estimate parking charges.

  - Only 24% estimated that parking might be free whereas 55% of car riders use free parking.

  - At the other end of the scale more transit users believe charges to be very much higher than in reality as stated by auto users.

Figure 4.1.12
PARKING TIMES

ESTIMATED PARKING TIME (MINUTES)	TRANSIT USERS	AUTO USERS
< 6	55%	81%
6 - 10	23%	10%
11 - 15	11%	4%
16 - 20	6%	3%
> 20	5%	2%

Figure 4.1.13
PARKING CHARGES

PARKING CHARGE ($ MONTH)	TRANSIT USERS	AUTO USERS
0	24%	55%
1 - 10	2%	3%
11 - 20	3%	3%
21 - 30	3%	3%
31 - 40	4%	2%
41 - 50	2%	3%
51 - 60	3%	1%
> 60	59%	30%

Figure 4.1.14
AUTO USERS COST SHARING

RESPONSE	YES	NO	TOTAL
Do you share costs?	32%	68%	100%

Figure 4.1.15
ALTERNATIVES TO AUTO

ALTERNATIVES	YES	NO	TOTAL
CTA Services	78%	22%	100%
Metra/Pace	35%	65%	100%

(14) Cost Sharing Among Auto Users

In question 5c car drivers were asked if they shared travel costs with one or more passengers.

- As shown in figure 4.1.14, roughly one third of drivers shared costs with their passengers; a fairly high proportion.

(15) Alternatives for Auto Users

Questions 5d and 5e asked car users if they could alternatively travel to work by CTA or Metra/Pace.

- The answers are shown in Figure 4.1.15; 78% could use CTA; and 35% Metra/Pace.

(16) Sample Representivity

Because parameters estimated from the survey may be aggregated over mode, CBD/non-CBD and journey length it was necessary to reweight the survey results to represent true proportions in each class.

- Surveys inevitably contain bias, especially in one such as the Place of Work Survey where respondents formed a self-selected sample.

- The 1980 Journey to Work survey gives a good estimate of the true proportions. Figure 4.1.16, following this page, shows the absolute numbers from the 1980 survey with CTA and Metra combined for transit.

  - The lower half shows the Place of Work Survey numbers.

Figure 4.1.17 converts the previous table to proportions of the total trips in each survey, and Figure 4.1.18 contains the bias correction factors calculated from the relative proportions.

Figure 4.1.16

SAMPLES BY MODE, JOURNEY LENGTH AND CBD\NON CBD

SOURCE		SHORT < 2 Miles	MEDIUM 2-6 Miles	LONG > 6 Miles	TOTALS
1980 SURVEY					
AUTO	:CBD	2,142	36,985	24,742	63,869
	:NON CBD	166,304	349,791	308,080	824,175
					888,044
TRANSIT	:CBD	9,166	118,240	52,951	180,357
	:NON CBD	30,407	78,811	56,035	165,253
					345,610
TOTAL SURVEY					1,233,654
PLACE OF WORK SURVEY					
AUTO	:CBD	-	25	66	91
	:NON CBD	25	47	73	145
					236
TRANSIT	:CBD	22	163	505	690
	:NON CBD	19	72	109	200
					890
TOTAL SURVEY					1,126

Figure 4.1.17

SAMPLE PROPORTIONS

SOURCE	SHORT < 2 Miles	MEDIUM 2-6 Miles	LONG > 6 Miles	TOTALS
1980 SURVEY				
AUTO :CBD	0.002	0.030	0.020	0.052
:NON CBD	0.135	0.284	0.250	0.668
TRANSIT :CBD	0.007	0.096	0.043	0.146
:NON CBD	0.025	0.064	0.045	0.134
TOTAL SURVEY:	0.169	0.474	0.358	1.000
PLACE OF WORK SURVEY				
AUTO :CBD	-	0.022	0.059	0.081
:NON CBD	0.022	0.042	0.065	0.129
TRANSIT :CBD	0.020	0.145	0.448	0.613
:NON CBD	0.017	0.064	0.097	0.178
TOTAL SURVEY:	0.059	0.273	0.669	1.000

Figure 4.1.18

FACTORS TO BE APPLIED TO PLACE OF WORK SURVEY RESPONSES

	SHORT < 2 Miles	MEDIUM 2-6 Miles	LONG > 6 Miles
AUTO :CBD	-	1.43	0.34
:NON CBD	6.07	6.79	3.85
TRANSIT :CBD	0.38	0.66	0.10
:NON CBD	1.46	1.00	0.47

- Relatively, auto non-CBD was the least well represented parameter in the Place of Work Survey and therefore these have the largest factors (3.85 - 6.79) to improve representivity.

- At the other end of the scale, CBD transit was over-represented (factors: 0.10 - 0.66), especially for long trips.

- These factors can be applied to estimated parameters when aggregating for modeling purposes.

2. PARAMETER ESTIMATES

This section presents the Place of Work Survey parameter estimates. The data is first analyzed descriptively using the Analysis of Means technique. Then, parameter estimates derived from the three disaggregate estimation techniques are compared. Parameters estimated on the total data base are compared in terms of demand elasticities and values of time prior to market segmentation.

(1) Analysis of Means

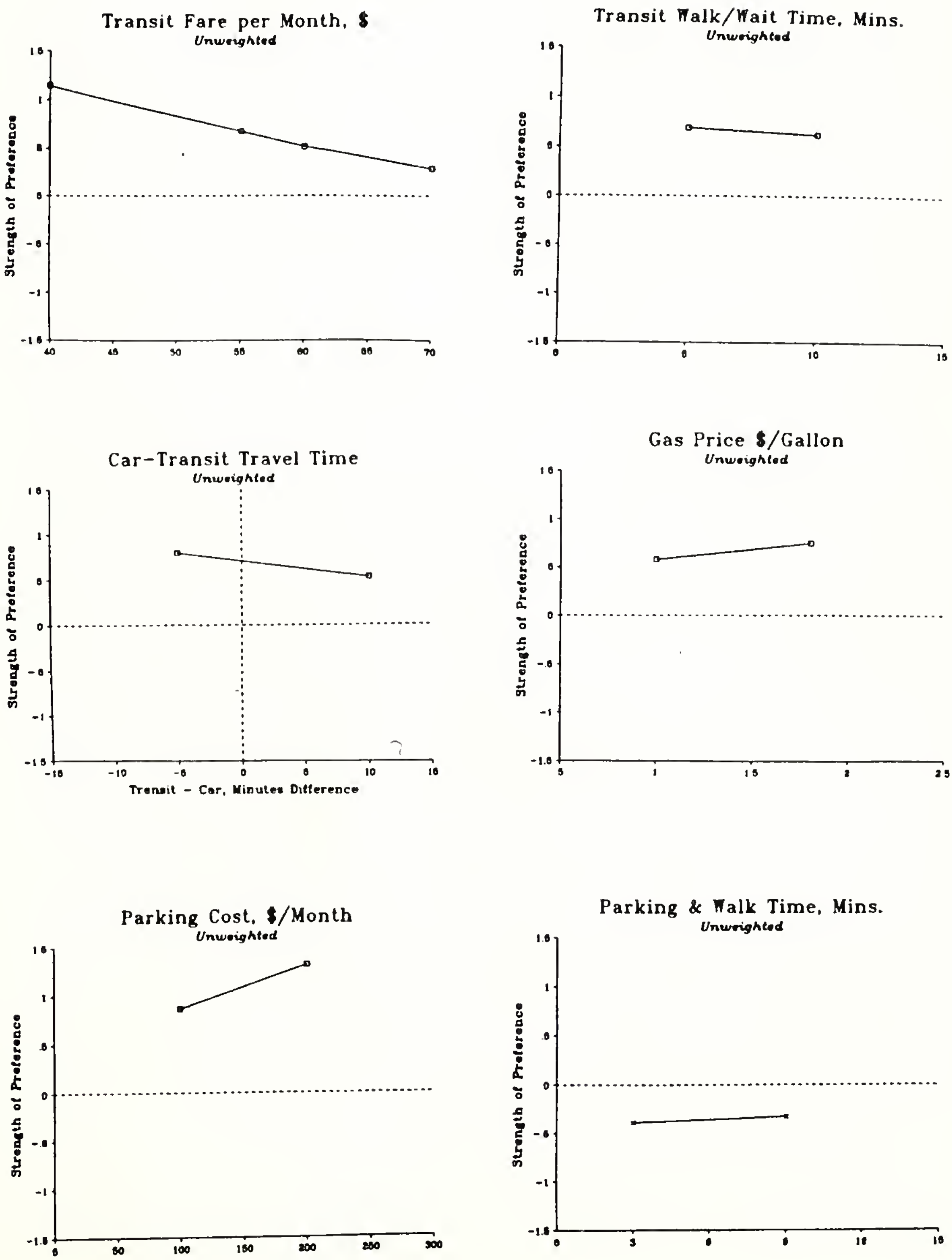
A preliminary analysis of stated preference responses was undertaken using the mean strength of preference as described in Section III.

- Figure 4.2.1, following this page, presents unweighted response mean scores.

  - Six graphs are presented; one for each attribute. In each graph the horizontal axis represents the level of the attribute and the vertical axis the mean score.

- Transit fare had four levels in the design: four mean scores were therefore plotted.

Figure 4.2.1
MEAN STRENGTH OF PREFERENCE -- UNWEIGHTED SCORES



  - The graph shows a near linear relationship. The relationship had the correct negative slope.

- Transit walk/wait time, as with parking and walk time for car had little impact on strength of preference.

- Parking cost shows a relatively high sensitivity.

  - Some caution should be used in comparing graphs because of scale-dependency.

Figure 4.2.2 provides a market segmented analysis of the relationship between strength of preference and fare.

- o A comparison of travelers to the CBD and non-CBD shows a greater sensitivity to fare amongst the latter group and higher absolute preference for car:- possibly a reflection of the radial nature of the transit network.

- o The non-CBD relationship exhibited some non-linearity.

  - It is possible that an S-shaped relationship may be more appropriate.

- o Men and women had similar strength of preferences with respect to transit fare. Women, however, had a somewhat higher absolute preference for car.

- o Household income had relatively little effect on either sign or absolute preference.

- o Poorer travelers appeared marginally more fare sensitive and had less absolute preference towards transit.

  - With the lower income profile of the black population it is not surprising that the high and low income differences are reflected in the race segmentation.

- o The higher level of absolute preference towards the car amongst black and low income respondents may reflect their higher perception of the status value of car travel.

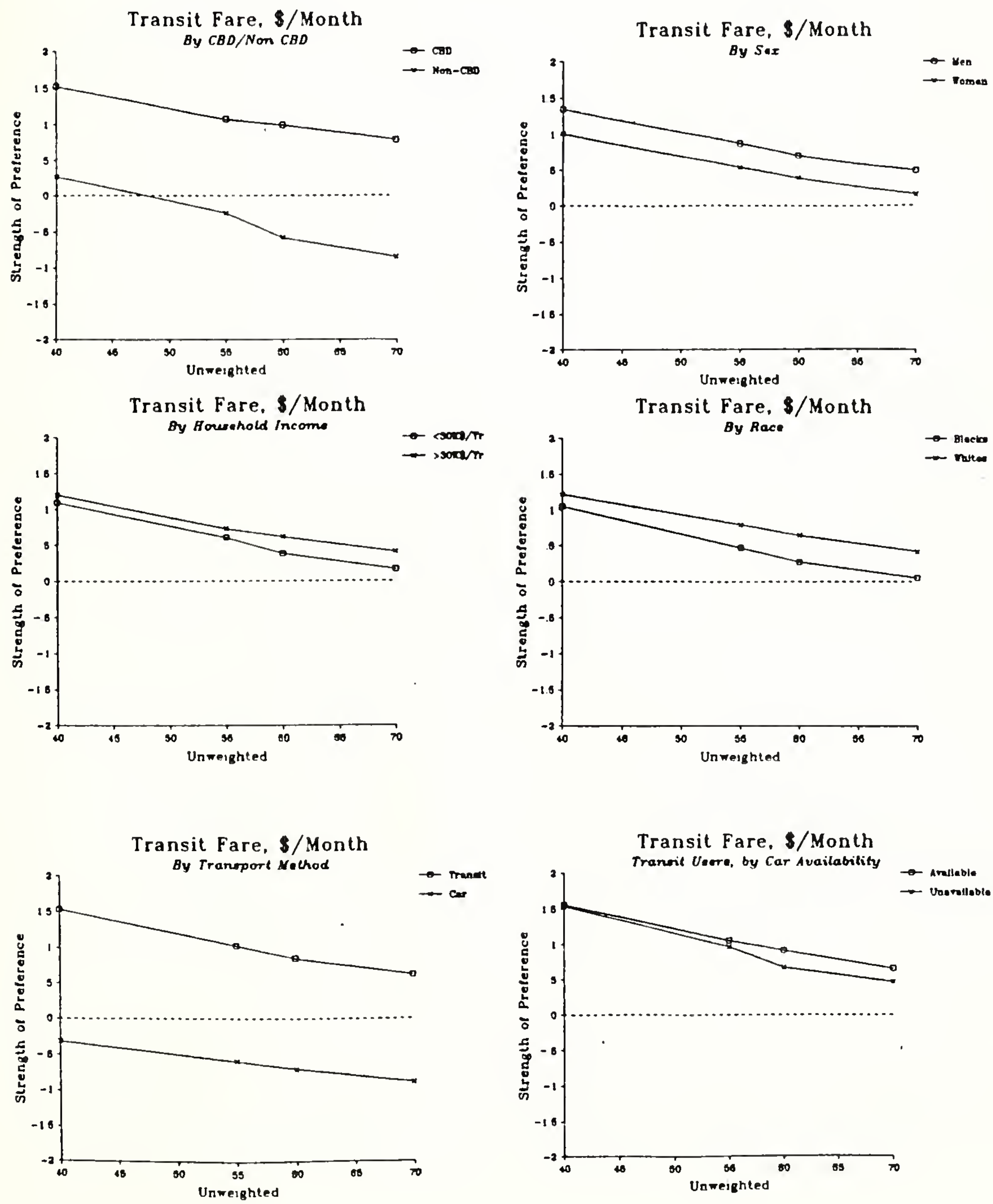
The most marked differences are apparent when response is disaggregated by travel mode use.

- o Travelers had a strong preference for the mode they actually use.

- o Car users appeared marginally less fare-sensitive than transit users.

- o The final comparison, between respondents with and without a car available, reveals little difference.

Figure 4.2.2
RELATIONSHIP BETWEEN STRENGTH OF PREFERENCE AND FARE BY MARKET SEGMENT



- Those who do not have a car available had a slightly stronger preference for car travel.

The importance of mode used and CBD/non-CBD on fare sensitivity suggested the need to weight responses to provide average population ratings.

- Figure 4.2.3, following this page, presents the equivalent results with responses to weighted to reflect mode share by market segment in Chicago as a whole.

- The dominant effect of weighting is to shift the curves downwards rather than alter their gradient. All curves retain the correct slope.

- This downward shift of all the curves reflects an under-representation of car users in the sample who, as a group, showed greater sensitivity to car attributes than transit attributes.

    - The most marked shifts were observed for transit variables. This reflects a strong modal bias against transit by non-CBD car users for whom the pre-dominantly radial pattern of transit services provides a poor alternative and who were most under-represented.

- The increased slope for transit time is consistent with the under-representation of car users.

- Walk/wait time, which had little impact on the strength of preference between transit and car in the unweighted data, has a more marked influence a similar effect is apparent in the car transit travel time attribute.

(2) Parameter Estimates: All Observations

Parameter estimates produced by the three disaggregate estimation techniques (Linear Strength of Preference; Log Odds and Inferred Mode Use) are presented in Figure 4.2.4.

Figure 4.2.3
STRENGTH OF PREFERENCE WEIGHTED TO REFLECT MODE SHARE BY MARKET SEGMENT

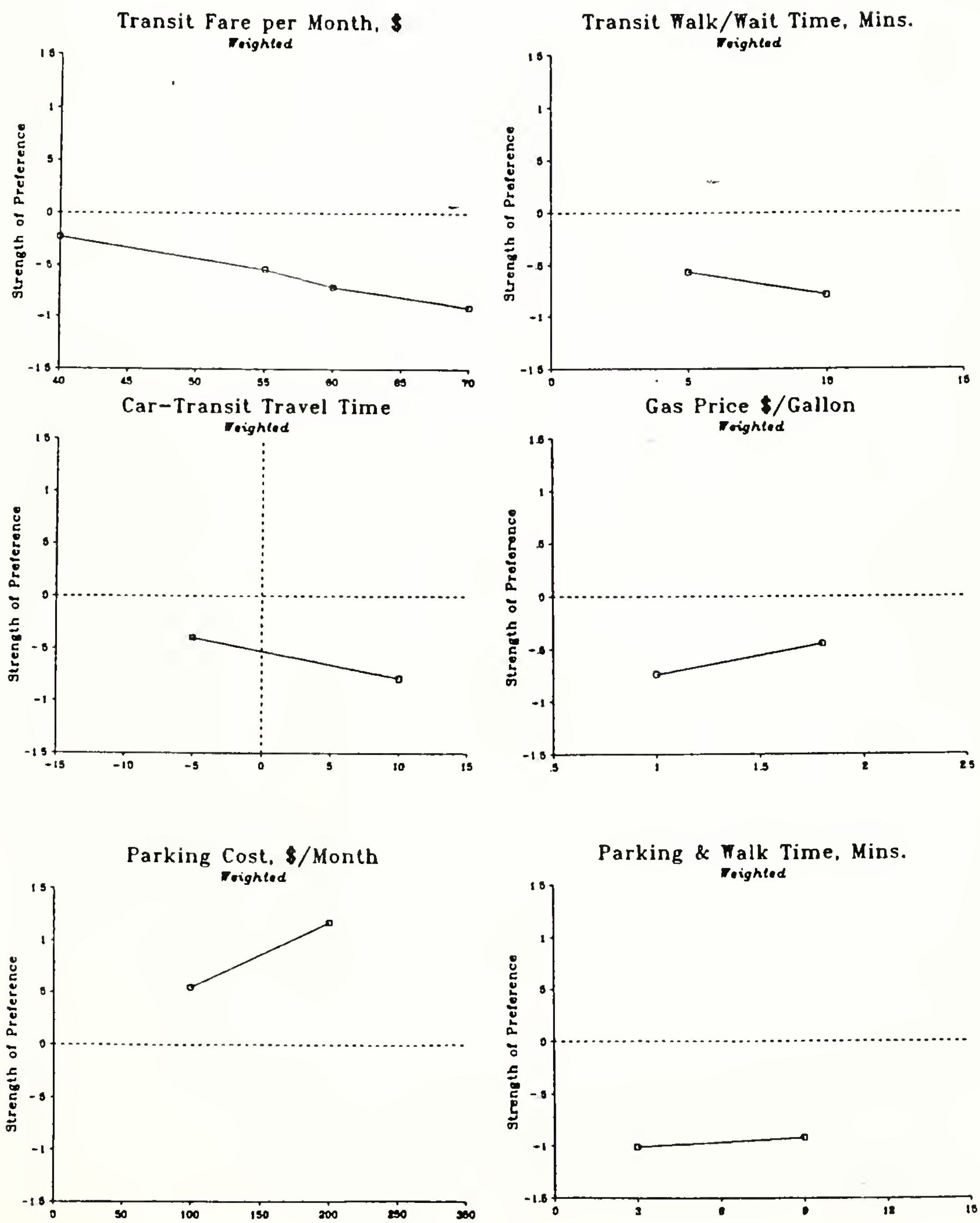


Figure 4.2.4

PLACE OF WORK PARAMETER ESTIMATES
Analysis Comparison: All Obervations

PARAMETER	<----Unweighted ----> Linear S of P	Log Odds	Inferred Mode Use	<----- Weighted ----> Linear S of P	Log Odds	Inferred Mode Use
FARES	-.029	-.032	-.035	-.023	-.025	-.028
$/MONTH	17.8	18.2	14.4	13.6	13.6	12.4
TRANSIT WALK/WAIT TIME	-.015	-.016	-.021	-.013	-.014	.01
MINS/TRIP	2.1	2.2	2	1.7	1.8	1
TRAVEL TIME DIFFERENCE *	-.018	-.02	-.021	-.026	-0.28	-.032
MINS/TRIP	7.7	7.8	6.1	10.7	10.6	9.9
GAS PRICE	.211	.23	.245	.363	.396	.328
$/GALLON	4.8	4.8	4.8	7.9	8	6.7
PARKING CHARGES	4.595	4.959	6.012	6.473	6.946	8.155
$/MONTH X 1000	10.9	10.9	9.9	7.9	7.8	7.4
PARKING TIME	8.247	9.731	6.595	13	15	14
MINS/TRIP X 1000	.7	.8	.4	1.9	2	1.5
CONSTANT	1.404	1.541	1.674	-.699	-.767	-.724
r^2/Rho^2 **	.064	.064	.04	.053	.053	.036
STANDARD ERROR	1.55	1.678		1.61	1.739	
N	7737	7737	7737	7652	7652	7652

NOTES: Upper Figure B; Lower Figure t
* Transit - Car
** W.R.T. Constants

- o The parameters have been estimated on the total data base without market segmentation. Both unweighted and weighted estimates are presented.

  - The weighted estimates were produced by weighting observations according to the CBD/distance market segment shown by travel mode.

  - Care was taken to ensure that the degrees of freedom were not increased by weighting, which could artificially inflate parameter significance.

The key findings are:

- o Trading off (different response by Strength of Preference generation) was sufficient to estimate parameters of correct sign and reasonable size.

- o Both transit factors (fare and walk/wait time) took negative sign implying that the preference for and the probability of using transit declines as fare and walk/wait time increase.

- o The car factors (gas price, parking time and parking time) took negative sign; increases in these factors increased the preference towards transit.

- o The parameter estimate for travel time difference took negative sign. The specification of the variable meant that as transit becomes quicker relative to car, the travel time difference becomes smaller (or more negative). The negative sign was therefore intuitive; as transit becomes quicker the preference for transit increases.

- o The sign and size of the constant parameter indicates the direction and extent of any "unexplained" preference for transit. A positive constant indicates a preference towards transit, a negative constant indicates preference away from transit.

- All factors had high statistical significance except parking time (unweighted observations) and transit walk/wait time (weighted observations), but relatively weak overall model explanation. This is a common finding in this type of research.

- The coefficient of determination adjusted for degrees of freedom (R bar squared) provided a measure of model goodness of fit for the Linear Strength of Preference and Log Odds models. For the Inferred Mode Use model, the equivalent statistic is the rho bar squared. However, comparisons of the estimation techniques based on goodness of fit may be misleading because of the different transformations of the dependent variable which, affects the total variation explained by the Stated Preference factors. (Log likelihood measures are more valid but more difficult to interpret.)

- Parameter significance can be assessed by reference to the reported "t" values (tabulated independent of sign). The higher the "t" value, the greater the precision of estimate. In Stated Preference experiments, the estimation error derives from:

  - The limited nature of the dependent variable

  - The limited number and range in the levels taken by the Stated Preference factors

  - Mistakes in completing each Stated Preference question by individual respondents

  - Mis-specification of the true functional relationship between preference and the Stated Preference factors

  - Variation in sensitivity to individual factors across individuals.

Care was taken to minimize each source of error during experimental design, survey implementation and analysis. Conventionally, estimates are considered acceptable with regard to statistical significance when

- The "t" exceeds two;

- The parameter is significantly different from zero at the 95% confidence level.

The results of this study met this criteria for transit fare - the key parameter. Values of t ranged from 12.4 to 18.2, depending on estimation technique and observation weighting. The criterion was, however, not met for transit walk/wait time unweighted observation and car parking time (except Log Odds weighted observations).

- o Weighting observations affected parameter estimates

- o The unweighted models estimated a positive constant implying an unexplained preference towards transit. The weighted models showed the reverse; a preference towards car and away from transit. The effect was shown visually in the figures 4.2.1 - 4.2.3. This results from a preference towards the respondent's current mode and the under-representation of car users. For similar reasons, weighting produced an increase in parameter size for car factors and a reduction for transit factors. The parameter for travel time difference also increased suggesting greater sensitivity to time among car users.

- o Parameter significance measured in terms of "t" value was also affected by the under-representation of car respondents. The under representation of travelers to non CBD destinations caused an increase in the significance of the parking time parameter and a fall in significance of the parking cost parameter.

- o Analysis technique affected the size of the parameter estimate.

- o The ordering was as follows: Inferred Mode Use > Log Odds > Linear Strength Preference. This ordering was expected given the preference conversions adopted.

- o The Log Odds parameters were approximately 10% greater than the Linear Strength Preference. The percentage difference in Inferred Mode Use parameters depended on the relative number of weak and

strong preferences for transit and car by question. For transit fare, the Inferred Mode Use parameter Stated Preference about 10% greater than the Log Odds parameters (9% unweighted, 12% weighted).

- Parameter significance also differed by estimation technique. For all but two parameters, the Log Odds parameters had the highest "t" values. In the case of transit fare unweighted observations, the Log Odds technique was .4 superior to the Linear Strength of Preference technique and .8 superior to the Inferred Mode Use technique. For weighted observations, the Log Odds and Linear Strength of Preference techniques had identical "t" values; both were 1.2 superior to the Inferred Mode Use technique. These findings recommended the Log Odds technique.

(3) Tests of Reasonableness

Tests were performed to assess the reasonableness of the parameters for:

- The implied elasticity of demand;
- The implied values of time; and,
- The ability of the parameters to replicate and actual mode choice

These tests were described in Section III. This section details the results when applied to the parameters estimated.

(4) Implied Elasticities of Demand

Figure 4.2.5, following this page, presents elasticity of demand measures for each factor estimated at the mean of the data series. These are representative elasticities as defined in Appendix B. They depend on:

- The parameter estimate (B);
- The mean value of the factor;

o The mean value of the probability of using transit (P_t)

The table shows weighted and unweighted elasticities for each technique. The mean value of P_t differed according to the strength of preference conversion.

FIGURE 4.2.5

ELASTICITIES OF DEMAND
PLACE OF WORK

ELASTICITIES	FACTOR MEAN	UNWEIGHTED LINEAR S of P	UNWEIGHTED LOG ODDS	UNWEIGHTED INFERRED MODE USE	WEIGHTED LINEAR S of P	WEIGHTED LOG ODDS	WEIGHTED INFERRED MODE USE
Transit fare,$/month	56.25	-.664	-.666	-.610	-.882	-.872	-1.024
95% Confidence Interval		.073	.072	.083	.127	.126	.162
Transit walk/wait,mins	7.50	-.046	-.044	-.049	-.665	-.651	-.049
95% Confidence Interval		.043	.040	.048	.767	.709	.096
Travel time difference	7.50	-.055	-.056	-.049	-.133	-.130	-.156
95% Confidence Interval		.014	.014	.016	.024	.024	.031
Gas price,$	1.40	.120	.119	.106	.347	.344	.298
95% Confidence Interval		.049	.049	.043	.086	.084	.087
Parking cost,$/month	150.00	.281	.275	.280	.662	.646	.795
95% Confidence Interval		.050	.049	.055	.164	.162	.211
Parking time,mins	6.00	.020	.022	.011	.053	.056	.055
95% Confidence Interval		.056	.053	.054	.055	.055	.071

TRANSIT PROPORTIONS	LOG ODDS	INFERRED MODE USE
unweighted	.63	.69
weighted	.38	.35

- For the Log Odds technique, the Stated Preference probabilities (.9, .7, .1) were summed and expressed on a percentage of the total Stated Preference response (giving a mean value of Pt of 0.6). The same mean P_t was used for the Linear Strength of Preference technique (the parameter estimates were, however, factored by 1.1, see Appendix B).

- The P_t measure for the Inferred Mode Use technique was calculated by expressing the sum of strong plus weak transit preferences plus one half times the number of indifferent responses as a proportion of the total response.

- The mean values of P_t were most noticeably affected by observation weighting. Unweighted observations showed a preference towards transit (P_t = .63; Log Odds). Conversely weighted observations showed a preference towards car (P_t = .38; Log Odds). The effect on P_t by the strength of preference conversion was less marked and differed according to observation weighting.

- Transit fare was estimated to have the highest elasticity. For the unweighted Log Odds model, the elasticity was estimated to be -.67. A 10% increase in transit fare on the mean fare of $56.25 per month in the Stated Preference design would induce a 6 - 7 % reduction in transit share. The other monetary factors, gas price and parking cost were estimated to have considerably lower elasticities of .12 and .28 respectively (unweighted). The time factors for unweighted observations showed that transit walk/wait and travel time difference were estimated to have roughly equivalent elasticities of around -.05; parking time had the lowest elasticity (0.02).

- Weighting observations produced larger elasticities because of the reduction in P_t; the elasticity measure is formulated on $1-P_t$.

    - The fare elasticity rose to -.87.

    - Car factors had greater increases in elasticity because of the positive effect of weighting on parameter estimate.

- Elasticity values varied only slightly by estimation technique. The Linear Strength of Preference and Log Odds elasticities were nearly identical; the Inferred Mode Use elasticities differed more noticeably, although the direction of effect was neither consistent nor statistically significant at the 95% confidence level.

  - The unweighted fare elasticity was lower (-.61 compared to -.67) the transit walk/wait time elasticity was higher (-.05 compared to -.04).

(5) Implied Value of Time

Figure 4.2.6 presents values of the following three time based factors evaluated in terms of transit fare:

- Overall travel time difference factor
- Transit walk/wait time
- Parking time

Relative valuations of the other monetary factors are also presented:

- Parking cost
- Gas price

It was necessary to standardize all factors as described in Appendix B. The 95% confidence range surrounding the mean valuation is also presented (Appendix B, equation (B22) provides the formula used).

- The value of overall travel time (based on the travel time difference parameter) differed significantly with observation weighting. Without weighting the mean valuation was around 90 cents per hour with a 95% confidence range of +/- 18 cents per hour. Weighting observations produced significantly higher value of time of around $1.70 per hour with a 95% confidence range of +/- 45 to 50 cents per hour. This indicates a relatively higher sensitivity of car use to overall travel time changes than to transit fare changes compared to transit users.

FIGURE 4.2.6

VALUES OF TIME AND RELATIVE MONETARY VALUATIONS
PLACE OF WORK

Parameter	Unweighted Linear S of P	Unweighted Log Odds	Unweighted Inferred Mode Use	Weighted Linear S of P	Weighted Log Odds	Weighted Inferred Mode Use
Travel Time Value, c/hr	93	93	90	169	168	171
S.E.	28	28	35	37	37	41
Transit Walk/Wait Time, c/hr	77	75	90	84	84	53
S.E.	74	68	90	100	93	107
Parking Time. c/hr	42	45	28	84	90	75
S.E.	16	16	20	21	21	23
RELATIVE VALUATIONS						
Parking Cost/Transit Fare	.16	.15	.17	.28	.28	.29
S.E.	.02	.02	.02	.05	.04	.05
Gas price/Transit Fare	.52	.51	.50	1.13	1.13	.84
S.E.	.12	.12	.12	.35	.35	.24

The mean value of transit walk/wait time was less than overall travel time. However, the difference was not significantly different at the 95% confidence level (t = 1.23 Log Odds, technique).

- o As with overall travel time, weighting observations produced a higher valuation of parking time. For the Log Odds model the weighted observation valuation was twice the unweighted valuation: - 90 cents per hour compared to 45 cents per hour.

- o Car users were clearly more sensitive to change in parking time than transit users.

- o The relative valuations of parking cost and gas price suggested different perceptions of the value of transit, parking and gasoline. Observations weighting also showed the increased sensitivity of car users to parking and gasoline price changes.

(6) Validation of SP parameter on Actual Mode Choice

A validation exercise was performed on the full Place of Work database.

- o The Stated Preference parameters were used together with the estimated times and costs of actual and rejected travel modes to build generalized cost functions for each respondent in the database.

- o Then, using the logit model presented in Appendix B, the generalized cost functions were validated against actual mode choice.

Validation was performed on the unweighted data set. Accordingly, the unweighted Stated Preference parameters were uses to build the generalized cost functions. the results are presented in Figure 4.2.7 for each of the three disaggregate estimation techniques.

Figure 4.2.7

VALIDATION PARAMETERS

Stated Preference Estimation Technique	Constant	Utility Difference
Linear Strength of Preference	1.2 (15.3)	.92 (.9)
Log Odds	1.2 (15.4)	.92 (.9)
Inferred Mode Use	1.24 (15.8)	.82 (2.2)

Number of Observations = 1126

Notes: Estimated as the probability of using transit
|t| values in parenthesis :
For constant |t| for B = 0
For utility difference |t| for B = 1

The validation exercise revealed:

- o A significant underestimation of the underlying preference for transit implied by the Stated Preference estimated constant term;
- o A tendency to overestimate the sensitivity to the utility difference between transit and car.
- o The over estimation of the sensitivity to utility difference was implied by a validation constant of positive sign and high significance (|t| far in excess of two).

- The over-estimation of the sensitivity to utility difference was implied by a validation parameter less than one. The extent of overestimation ranged between 10% and 20% depending upon Stated Preference estimation technique. The Inferred Mode Use technique over-estimated by the greatest amount. The Linear Strength of Preference and Log Odds techniques produced near identical validation parameters which did not differ significantly from one (i.e. no adjustment is implied).

Despite these encouraging results, the validation is not considered a powerful test of the reasonableness of the individual Stated Preference parameters, particularly transit fare. The test assumes that the validation parameters apply equally to all constituent factors of utility difference, irrespective of the cross-sectional variation within the database.

Most of the variation in estimated factor cost/time was captured in overall travel time and in parking cost/time as shown in Figure 4.2.8, following this page.

- Car users estimated car travel time to be less than transit travel time by 15 minutes compared to transit users who estimated the difference to be only 4 minutes. Car users estimated their parking cost (CBD) to be lower ($76/month) than the cost estimated by transit users ($111/month). Similarly, car users estimated parking time (non-CBD) to be half (3 mins) the time estimated by transit users (6 mins). These factors accounted for most of the variation in modal cost. In contrast, there was little noticeable difference in transit fare and transit walk/wait time. Car users estimated the transit fare they would have had to pay at $52/month: $3 more than the fare stated by transit users.

These findings suggest the validation exercise to be a reasonable test of the travel time and parking cost parameters (which performed well), but a weaker test of the reasonableness of the transit fare and transit walk/wait parameters because of the much reduced variation in estimated costs/times between car and transit users.

(7) Market Segment Parameter Estimates

Figure 4.2.9 presents market segment parameter estimates and parameter "t" values. Unweighted observations have been segmented according to:

FIGURE 4.2.8

MEAN FACTOR VALUES BY ACTUAL TRAVEL MODE

	Car	Transit
Transit Fare ($/month)	52	49
	(18)	(19)
Transit Overall Travel Time	54	46
(mins/single trip)	(24)	(22)
Car Overall Travel Time	29	42
(mins/single trip)	(20)	(16)
Transit Walk Wait Time	13	15
(mins/single trip)	(11)	(12)
Park Time non-CBD respondents	3	6
(mins/single trip)	(4)	(5)
Park Cost CBD respondents	76	111
($/month)	(48)	(42)
No. of observations all	236	890
" CBD	91	690
" non-CBD	145	200

NB. gas cost was not asked; it was entered as 160c/gallon for all respondents.

Standard error in parenthesis.

FIGURE 4.2.9

PLACE OF WORK MARKET SEGMENT PARAMETER ESTIMATES
LOG ODDS ANALYSIS *

	SEX		RACE		INCOME		TRAVEL MODE		DESTINATION			DISTANCE **		CAR AVAILABILITY	
	MALES	FEMALES	WHITES	OTHERS	<30K	>30K	TRANSIT	CAR	CBD	NON CBD	<2MLS	2-6MLS	>6MLS	AVAILABLE	UNAVAILABLE
TRANSIT FARE	-.029	-.023	-.027	-.023	-.021	-.028	-.035	-.020	-.028	-.041	-.022	-.036	-.031	-.023	-.042
$/MONTH	-8.900	-10.600	-11.600	-6.900	-7.800	-10.300	-20.300	-5.300	-15.900	-12.200	-2.800	-10.600	-14.900	-12.400	-6.500
t Mean Difference	-1.533		-.984		1.830		-3.615		3.426		1.636		1.255	2.826	
TRANSIT WALK/WAIT	-.024	-.009	-.019	-.005	-.009	-.015	-.015	-.020	-.019	-.008	-.010	-.018	-.016	-.017	-.013
MINS/SINGLE TRIP	-1.700	-.981	-1.800	-.300	-.800	-1.300	-2.100	-1.200	-2.500	-.600	-.300	-1.200	-1.700	-2.100	.400
t Mean Difference	-.891		-.710		.372		.276		-.717		.219		.113	-.119	
TRAV TIME DIFF	-.040	-.022	-.032	-.024	-.022	-.035	-.018	-.028	-.015	-.030	-.023	-.025	-.018	-.029	-.015
MINS/SINGLE TRIP	-8.600	-7.100	-9.800	-4.900	-5.500	-9.000	-7.100	-5.000	-6.000	-6.000	-2.100	-5.100	-5.800	-11.000	-1.500
t Mean Difference	-3.221		-1.359		2.330		1.627		2.683		.167		1.207	-1.354	
GAS PRICE	.440	.373	.430	.309	.440	.365	.188	.387	.126	.464	.278	.281	.197	.390	.407
$/GALLON	5.000	6.300	6.800	3.400	5.900	5.100	4.000	3.700	2.600	5.000	1.300	3.000	3.500	7.700	2.300
t Mean Difference	.632		1.093		.726		-1.735		-3.229		-.013		-.769	-.092	
PARKING COST	7.177	6.538	7.374	6.378	5.090	8.062	4.206	.010	4.952		4.184	6.495	4.500	7.579	2.877
$/MONTH	5.400	5.500	6.200	4.300	3.300	7.100	10.000	7.900	13.000		1.400	6.900	8.700	8.000	1.800
t Mean Difference	.358		.524		-1.552		9.976				-.738		-1.857	2.531	
PARKING TIME	-.011	-.026	.013	.017	.019	.012	.002	.021		.009	-.011	.008	.014	.014	.021
MINS/SINGLE TRIP	-.800	3.000	1.400	1.200	1.700	1.100	.100	1.200		.800	-.300	.380	.900	1.900	.700
t Mean Difference	.923		-.236		.448		-.715				-.449		.229	-.227	
CONSTANT	.074	-1.137	-.633	-.822	-.988	-.565	2.287	-1.548	2.003	1.365	.284	1.277	1.748	-1.030	1.648
	.200	-4.600	-2.500	-2.400	-3.100	-2.100	13.800	-4.200	13.800	5.100	.300	4.000	8.700	-5.000	2.600
t Mean Difference	2.722		.444		-1.014		9.490		2.095		-.994		1.249	-4.018	
R^2	.076	.044	.062	.041	.038	.065	.087	.071	.081	.083	.021	.086	.063	.054	.068
S.E. of Estimate	1.750	1.680	1.740	1.740	1.720	1.760	1.450	1.697	1.391	1.760	1.831	1.680	1.620	1.700	1.800
N	2503	5101	4736	2264	3339	3737	6077	1660	5313	2270	477	2033	5082	6957	638

NOTES:-

* Upper figure = parameter estimate.
Middle figure = parameter t value.
Lower figure = t value for difference in mean estimates.

** Base group for difference in means test is 2-6 miles.

- Sex (males, females)
- Race (white, non-white)
- Income (household income < $30K, > $30K)
- Travel mode (transit, car)
- Destination (CBD, non-CBD)
- Distance (< 2 miles, 2-6 miles, > 6 miles)
- Car availability (car available, car unavailable)

The statistical significance associated with the difference in mean parameter estimates is also presented (lower figures).

All parameters presented in this section have been estimated by Log Odd Analysis.

The key findings were:

- Males were more sensitive to overall time than females, and to have a greater unexplained preference towards transit.
- There were no significant differences between whites and other racial groups.
- Respondents from households of income less than $30,000 per year had a lower sensitivity to transit fare, were less sensitive to parking cost and had a greater unexplained preference to transit.
- Travelers to the CBD compared to non-CBD destinations were less sensitive to transit fare, overall travel time and gas price, and, had a greater unexplained preference towards transit.
- There were no significant differences by travel distances

- o Respondents who had a car available for travel, compared to those without were less sensitive to transit fare, more sensitive to parking cost and had a lower unexplained preference towards transit.

3. CONCLUSIONS

The Stated Preference design worked reasonably well. A transit car mode split model could be estimated treating:

- o Rail and bus as composite models
- o Rail and bus as a composite transit mode
- o Car driver and car passenger as a composite car mode

Seven parameters were estimated of correct sign and of acceptable efficiency:

- Transit fare;
- Transit walk/wait time;
- Travel time difference;
- Car gas price;
- Car parking cost;
- Car parking time;
- Constant term indicating sign and size of any unexplained preference towards either travel mode.

The large data base provided by the self-completion mail back questionnaire allowed market segmentation of the data, and firm comparison of alternative analysis methods of the data to be performed.

- o However, self selection inherent in this type of distribution resulted in an under representation of car users and non-CBD trips with a corresponding over representation of transit users and CBD trips.

Observation weighting was applied to replicate Chicago population mode and destination figures weighted models were fitted and compared to the unweighted models.

- o Of the four analysis techniques, log adds analysis (which converts the Stated Preference response data into a measure of probability of using transit or car then fits a logistic function), was considered to provide the best results. It makes full use of the preference data provided at the individual question level, while having the theoretical advantage of the logistic formulation.

Nevertheless, the results from the different techniques were very similar, confirming the robustness of the data base.

Three tests of reasonableness were applied to the estimated parameters:

- Implied elasticities of demand;
- Implied value of time;
- Ability to replicate observed mode choices.

- o The tests suggested that the estimated sensitivity to transit fare may be slightly high. This could result from the distribution and collection method.

- o The fare elasticity estimated at the mean of the data was in excess of -.6 while the travel time difference elasticity was around -.06. This value reduces to -0.4 if the actual average fare of 83 cents per journey is assumed rather than the survey data set mean of $55 per month (i.e. $1.38 per journey).

The validation exercise found that the Stated Preference based on utility difference between transit and car accorded with actual mode choice reasonably closely. However, the underlying preference towards transit was under-estimated. Moreover, most of the variation in actual times/costs between transit and car users was confined to overall travel time and parking cost. The test did not provide very firm evidence of the validity of the transit fare parameter.

The extensive database allowed segmentations by individual respondent. Two significant differences in sensitivity to changes in transit fare were found:

- o Transit users were more sensitive than car users.

- o Travelers to the CBD were less sensitive than travelers to non-CBD destinations.

Other segmentations did not produce statistically significant differences in sensitivity.

Overall, the survey is considered to have been a success, providing much useful information on the sensitivity of travelers to changes in transit fare; user profile and travel mode perceptions.

V. ACTIVITY CENTER SURVEY RESULTS

V. ACTIVITY CENTER SURVEY RESULTS

The Activity Center Survey was conducted to gain a comprehensive database for non-work travel patterns in Chicago.

A total of 896 interviews were conducted at 25 activity centers, such as shopping precincts, leisure centers, hospitals and libraries. Respondents were randomly selected at the activity centers to avoid bias towards any travel mode.

1. SAMPLE DESCRIPTORS

Respondents who claimed they never used CTA services answered the socio-economic questions but were not asked about travel behavior. This group amounted to 112 of the total sample of 896.

(1) Arrival Mode

Figure 5.1.1 shows that transit enjoyed a large market share with 49% of the total. Auto had 41%, and 10% of the respondents walked.

Figure 5.1.1
Arrival Mode

Auto	Transit	Walk
41%	49%	10%
(367)	(433)	(84)

(2) Household size following this page

Figure 5.1.2 shows the household size profile.

There was an even spread of household size overall with roughly 20% in each category (1,2,3,4,5+ persons per household).

ACTIVITY CENTER [illegible]

[illegible]

Figure 5.1.2

HOUSEHOLD SIZE PROFILE OF RESPONDENTS BY TRAVEL MODE

PERSONS/ HOUSEHOLD	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
1	11%	21%	30%	18%
2	23%	22%	19%	22%
3	20%	16%	20%	18%
4	20%	18%	10%	18%
> 4	26%	23%	21%	24%
TOTAL:	100%	100%	100%	100%

Figure 5.1.3

CAR OWNERSHIP BY HOUSEHOLD

CARS/ HOUSEHOLD	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
0	7%	33%	43%	23%
1	37%	34%	38%	36%
2	35%	23%	13%	27%
3	12%	7%	2%	9%
> 3	9%	3%	4%	5%
TOTAL:	100%	100%	100%	100%

- Notable differences by mode included a low proportion of single person households in auto (11%) and a high proportion in walk (30%).

- This may reflect the family factor in non-work trips and the higher affluence (and hence car ownership) of 2+ person households.

(3) Car Ownership

Figure 5.1.3 on the previous page shows Car Ownership by Household.

Not surprisingly auto users had a high level of car ownership; only 7% (presumably the ride-share passengers) were not in a car owning household. One third of transit users and 43% of walkers did not own a car.

(4) Age

Figure 5.1.4 on the following page details the age profile of respondents.

The age distributions were similar for all modes with over 50% in the 18-34 range for each. There were relatively few young auto users (4%) and a relatively high proportion (17%) of old walkers, both of which seem intuitively reasonable.

(5) Household Income by Mode

Figure 5.1.5 on the following page details the household income of respondents.

The car users (approximately $32,000 pa) were generally more affluent than transit users (approximately $27,000 pa) who were in turn more affluent than walkers (approximately $25,000 pa). Almost three times as many walkers were in the lowest income group compared to car users.

Figure 5.1.4

AGE PROFILE OF RESPONDENTS BY TRAVEL MODE

AGE RANGE	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
< 18	4%	7%	8%	6%
18 - 24	26%	33%	26%	29%
25 - 34	30%	26%	26%	28%
35 - 44	18%	11%	16%	14%
45 - 64	14%	13%	7%	13%
> 64	8%	10%	17%	10%
TOTAL:	100%	100%	100%	100%

Figure 5.1.5

HOUSEHOLD INCOME PROFILE OF RESPONDENTS BY TRAVEL MODE

ANNUAL HOUSEHOLD INCOME	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
< 10,000	13%	22%	36%	20%
10,000 - 20,000	18%	21%	15%	19%
20,000 - 30,000	18%	19%	20%	18%
30,000 - 40,000	21%	17%	8%	18%
40,000 - 50,000	10%	8%	6%	9.0%
> 50,000	20%	13%	16%	16%
TOTAL:	100%	100%	100%	100%
Average Income:	32,000	27,000	25,000	28,000

(6) Sex Profile

Figure 5.1.6 on the following page shows the sex profile of respondents.

In general more females undertook non-work journeys, presumably because a higher proportion of males are engaged in daytime employment. As expected, transit is used by more females (64%) than males (36%) while the male/female split is more even among auto users (44:55 m:f)

(7) Race

Figures 5.1.7 on the following page shows the race profile of respondents.

Relatively fewer whites (46% in all) and more blacks (42%) were engaged in non work travel compared with the 56:31 split from the 1980 Journey to Work survey. The walk mode had a higher proportion of whites than the other two which were remarkably similar in their racial composition. There was therefore not much difference in-non work travel between the races.

The following sections deal with travel characteristics of the sample. Those who 'never' used CTA were excluded from this part of the interview leaving 784 respondents comprising:

- o 262 (33%) auto users
- o 436 (56%) transit
- o 86 (11%) walk

(8) Perceived distance

Perceived distributions of distance traveled did not differ greatly between transit and auto users. In both cases, 11-12% made short trips (less than 2 miles) while the rest were split broadly into medium and long trips. Auto users claimed to make more long trips than transit users, 47% vs 37%.

Figure 5.1.6

SEX PROFILE OF RESPONDENTS BY TRAVEL MODE

SEX	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
Male	45%	36%	33%	40%
Female	55%	64%	67%	60%
TOTAL:	100%	100%	100%	100%

Figure 5.1.7

RACE PROFILE OF RESPONDENTS BY TRAVEL MODE

RACE	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
Hispanic	9%	8%	7%	8%
Asian	2%	1%	2%	2%
Black	45%	43%	28%	42%
White	42%	46%	58%	46%
American Indian	0%	0%	2%	0.2%
Other	2%	2%	3%	2%
TOTAL:	100%	100%	100%	100%

Not surprisingly, 79% of walkers were making short trips and only 1% (one respondent) walked more than 6 miles. The results are shown in Figure 5.1.8 following this page.

(9) Market Segment

Transit's prime market segments are evenly split between medium and long journeys both inside and outside the CBD. Auto users made predominantly non CBD trips of medium and long distance. Walkers made mainly non CBD short trips. The sample clearly shows the dominance of transit inside the CBD. The results are shown in Figure 5.1.9 following this page.

(10) Trade off Administered

The stated preference experiment administered a trade-off between:

- o Transit-car
- o Transit-walk
- o Transit-not travel

The trade off administered depended on the travel mode used and, if this was transit, the second best alternative. The percentage distribution is shown in Figure 5.1.10 on the following page.

(11) Summary

- o Roughly half of the sample interviewed at activity centers used transit for all or part of their journeys. 41% used auto and 10% were short distance walkers.
- o Overall, household size was evenly spread.However on average car users came from larger households while walkers tended to come from one person households. transit feel between the two .
- o Car ownership and income were higher for auto users while walkers were apparently the least affluent in both cases.

Figure 5.1.8

PERCEIVED DISTANCE

DISTANCE (MILES)	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
< 2	11%	12%	79%	19%
2 - 6	43%	51%	20%	45%
> 6	47%	37%	1%	36%
TOTAL:	100%	100%	100%	100%

Figure 5.1.9

MARKET SEGMENTS

SEGMENTS	TRAVEL MODE			
	< 2 miles	2 - 6 miles	> 6 miles	Market Total
AUTO - CBD	0%	1%	5%	6%
- Non CBD	4%	13%	10%	27%
Total Auto				33%
TRANSIT - CBD	2%	14%	12%	28%
- Non CBD	5%	14%	9%	28%
Total Transit				56%
WALK - CBD	2%	1%	0%	3%
- Non CBD	7%	1%	0%	8%
Total Walk				11%
TOTAL:	20%	44%	36%	100%

Figure 5.1.10

TRADE OFF ADMINISTERED

TRADE OFF	TRAVEL MODE			
	Auto user	Transit User	Walk	Total All Modes
Transit/Auto	100%	50%	-	61%
Transit/Walk	-	11%	100%	17%
Transit/Not travel		39%	-	22%
TOTAL:	100%	100%	100%	100%

- o Age distributions were similar for all modes, and while women dominated non work travel as a whole (60:40 men:women), this was more prevalent among transit users and walkers.

- o Relatively more black people than white used cars (45:42) while the reverse was true for transit users (46:43 white:black).

- o Walkers were dominated by short trips, the other two modes were similar in distance but slightly more long (perceived) journeys were made by car.

- o Transit seemed to do equally well both inside and outside the CBD while auto was dominated by non CBD journeys. However, this was not surprising for a largely off-peak, non-work sample.

2. PARAMETER ESTIMATES

This section presents the Activity Center Survey parameter estimates.

1) Analysis of Usage of CTA Services

Respondents were asked about their past usage of CTA services.

- o Those that had never used CTA were not included in the stated preference experiment, but the socio-economic details of these users was obtained. This allowed an explanatory model to be estimated relating CTA usage to socio-economic characteristics. The estimated model is presented in Figure 5.2.1.on the following page.

The data set comprised 896 respondents; of these 112 (12.5%) stated they had never used CTA.

- o The model attempted to explain the cross-sectional variation in CTA usage (specified as Yes or Never) across individuals by reference to their socio-economic characteristics. The following characteristics were modeled:

FIGURE 5.2.1

ANALYSIS OF CTA USAGE: PROBABILITY OF USING CTA

Variable	Definition	Estimate
SEX	Males = 1 Females = 0	.388 (1.8)
INCOME 1 (Household)	Income)$10k = 1 Income ($10k = 0	.506 (1.3)
INCOME 2 (Household)	Income)$10k = 1 Income ($10k = 0	.4 (1.7)
AGE	Age)34 = 1 Age (34 = 0	.481 (2.2)
CARS PER HOUSEHOLD/HOUSEHOLD SIZE		.983 (4.5)
HOUSEHOLD SIZE	as stated	.257 (1.2)
CONSTANT	-	-3.62 (9.0)
Rho Squared with respect to zero		.497
Rho Squared with respect to constants		.074

FIGURE 5.2.2

SECOND BEST ALTERNATIVE PROFILE

Second Best Alternative	Number	Percentage
CAR	218	50
WALK	48	11
NOT TRAVEL	170	39
ALL TRANSIT	436	100

- Sex (males; females)
- Household income (<10,000: 10,000-30,000: >30,000)
- Age (<18: 18-35: >35)
- Cars per household
- Race (white: others)
- Household size

Characteristics were specified as binary variables.

o Together, the characteristics enabled the model to explain approximately 50% of the cross-sectional variation in CTA usage. not all variables were important as explanatory variables; for example, race did not contribute significantly to the explanatory power of the model.

The estimated parameters enabled the probability of an individual of given socio-economic characteristics to have used CTA services to be predicted.

o The predicted probabilities ranged from .59 to .97. The lowest probability, a 40% chance of the individual having never used CTA, was predicted for:

o Males aged over 34 with household income over $30,000 from a household of two people where each has a car.

The highest probability, implying only a 3% chance of never having used CTA, was predicted for:

o Females aged under 35, living alone, on incomes less than $10,000 and without a car.

(2) Analysis of the Second Best Alternative for Transit Users

Respondents who had traveled to the activity center by transit were asked their second best travel alternative (i.e., what they would have done if transit had not been available) to determine which stated preference experiment was to be completed.

The Second Best Alternative profile (also presented in percentage form in Figure 5.1.10) is presented in Figure 5.2.2 on previous page.

Variables similar to those in the CTA usage model were used to explain the cross sectional variation in Second Best Alternative

- o It was also possible to introduce distance as an explanatory variable making walk unavailable as a Second Best Alternative for distances over 6 miles.

The estimated 'best fit' model is presented in Figure 5.2.3 following this page.

Parameters were estimated for two of the three alternatives. Attempting to estimate the third parameter would over identify the equation; estimation would fail.

- o The probability of selecting car as the Second Best Alternative was more likely:
  - The greater the number of cars per household member
  - If the trip was to a CBD destination
  - If the respondent was white and less than 65 years of age.
- o The relationship between the probability of selecting car and household income was non-linear: respondents from less income households (-$10k) were less likely to select car; but respondents from high income households (+$30k) were also less likely to select car.

- The probability of selecting walk was less likely the further the trip distance. Also respondents aged over 65, white, from small households and with few cars available were less likely to walk if transit was unavailable.

(3) Analysis of Means

A preliminary analysis of the stated preference responses was undertaken using an analysis of means preference scores.

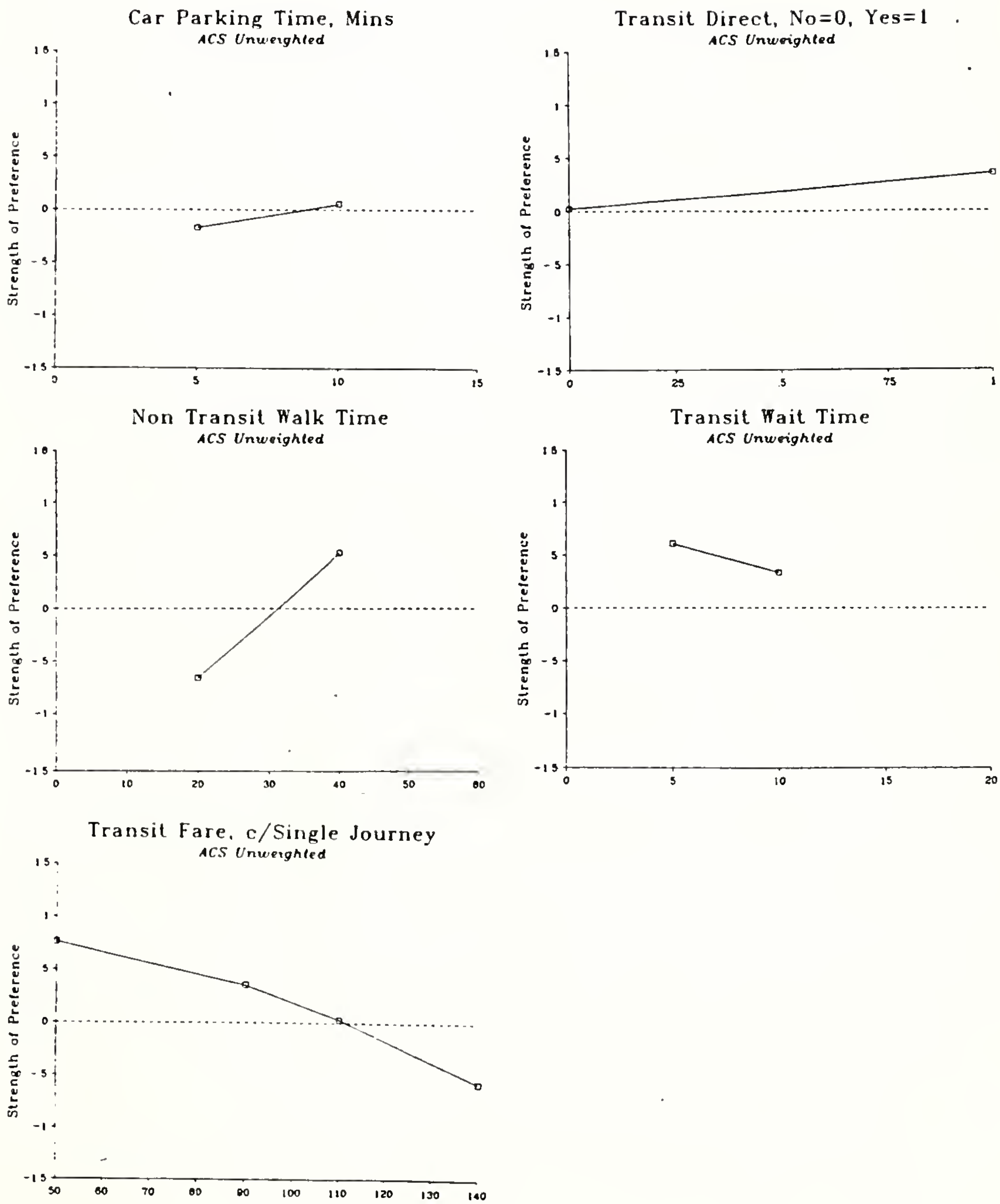
Figure 5.2.4 on the following page presents five mean score graphs: one for each of the factors in the experimental designs. The response to each of the three experimental designs has been combined.

FIGURE 5.2.3

ANALYSIS OF TRANSIT USERS SECOND BEST ALTERNATIVE

Variable	Definition	Estimate Car	Estimate Walk	Estimate Not Travel
INCOME 1 (Household)	Income)$10k = 1 Income ($10k = 0	-.397 (1.4)	-	-
INCOME 2 (Household)	Income)$10k = 1 Income ($10k = 0	.556 (2.2)	-	-
AGE3	Age)34 = 1 Age (34 = 0	-.921 (2.3)	-1.234 (1.8)	-
RACE	White = 1 Others = 0	.453 (1.9)	-.663 (1.5)	-
HOUSEHOLD SIZE		-	.148 (1.4)	-
CARS PER HOUSEHOLD MEMBER		1.435 (4.2)	.952 (1.8)	-
DESTINATION	CBD = 1 NCBD = 0	.323 (1.4)	-	-
DISTANCE		-	-.456 (3.4)	-
CONSTANT		-.606 (1.0)	-	.147 (0.3)
Rho Squared with respect to zero			.141	
Rho Squared with respect to constants			.092	

Figure 5.2.4
STRENGTH OF PREFERENCE MEAN SCORES
ACTIVITY CENTER SURVEY



The underlying preference towards or away from transit is indicated by the vertical position of the preference lines. This is affected by the experimental designs, only transit fare featured in all three:

- Non transit walk time, only featured in the transit/walk experiment
- Car parking time only featured in the transit/car experiment
- Transit wait time only featured in the transit not travel experiment.

Therefore, vertical positioning of the lines reflect differences in underlying travel mode preference of respondents to each stated preference experiment.

o Particularly noticeable is the higher vertical positioning of the preference line to the transit wait time graph, reflecting strong underlying preference towards transit and away from not traveling .

Comparison of the relative sensitivity to each factor is hampered by differences in unit and scale.

o Nevertheless, the greatest sensitivity appears to be associated with changes to transit fare and non transit walk time. The weakest sensitivity appear to be associated with changes to transit wait time and car parking time.

The strength of preference line with respect to transit fare is approximately linear, albeit with weak evidence of declining sensitivity to lower fares.

Figure 5.2.5 (2 pages) following this page presents market segment mean score graphs for transit fares. A total of eight graphs are presented; one for each of the following segmentations of response:

o Stated preference experiment (car, walk, not travel);

o Transport method (transit, car, walk);

- Car availability for transit users (available, unavailable);
- Race (whites, blacks, others);
- Destination (CBD, non CBD);
- Sex (males, females);
- Household Income (<$30,000, >$30,000);
- Age (under 18, 18-65, Over 65).

The key findings were:

- A strong preference towards transit by respondents to the transit- not travel stated preference experiment, but a less noticeable difference in sensitivity to transit fare.

Figure 5.2.5
MEAN SCORES FOR TRANSIT FARE BY MARKET SURVEY
ACTIVITY CENTER

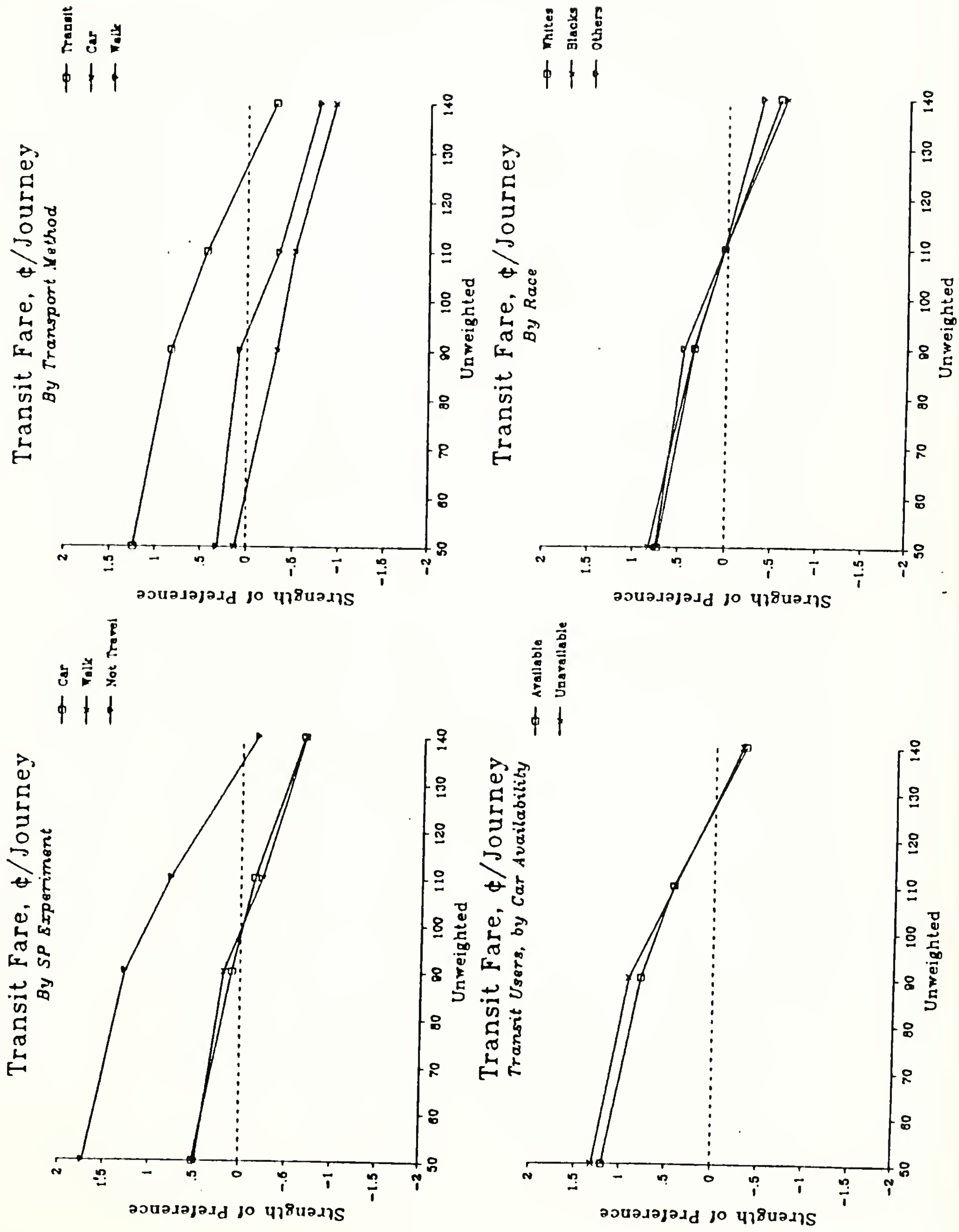
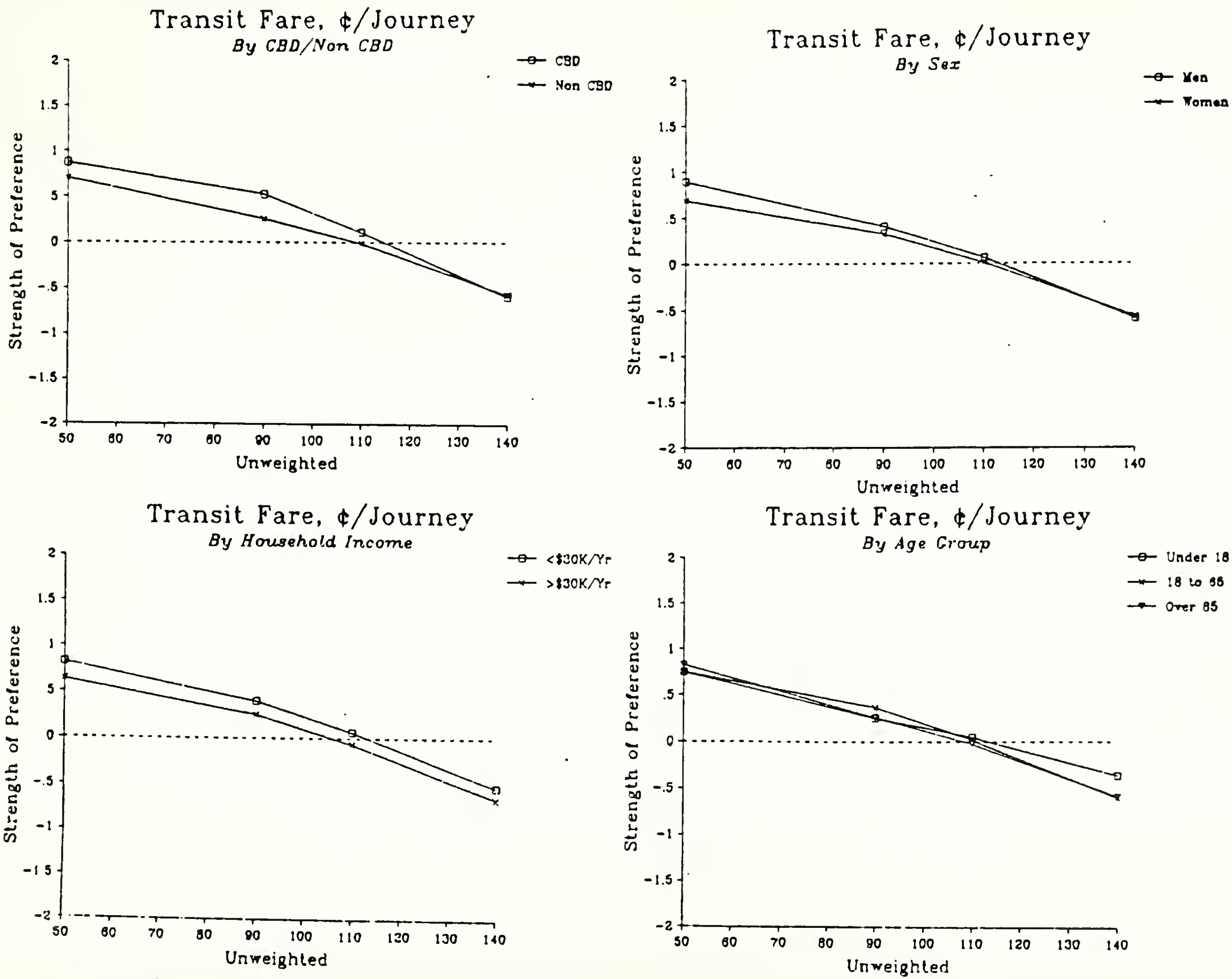


Figure 5.2.5
MEAN SCORES FOR TRANSIT FARE BY MARKET SURVEY
ACTIVITY CENTER



- Correlation of mode preference and current travel mode used:
  - Transit users preferred transit;
  - Non-transit users preferred their current mode (car or walk)

The sensitivity to transit fare was similar.

- Car availability (transit users only), race, and age group had little effect on either the underlying mode preference or sensitivity to transit fare.

- Travelers to the CBD showed a greater preference for transit and were more sensitive to changes in transit fare than travelers to non CBD destinations.

- Men showed a greater preference for transit and a slightly greater sensitivity to changes in transit fare.

- Respondents from households of income less than $30,000/year showed a greater underlying preference towards transit but had a similar sensitivity to changes in transit fare as respondents from households of income greater than $30,000/year.

(4) Parameter Estimates: All Observations

Parameter estimates produced by the three disaggregated estimation techniques (Linear Strength of Preference Log Odds and, Inferred Mode Use) are presented in Figure 5.2.6. The parameters have been estimated on the total data base, without market segmentation and with the response to the three experimental designs combined.

The key findings are summarized below:

- As with the Place of Work Survey there was sufficient trading off to estimate parameters of correct sign and reasonable magnitude.
  - Transit fare and transit wait time took correct negative sign.

- Transit change which took a value of one if the service was direct and zero if indirect, took positive sign; respondents would prefer transit if the service was direct rather than indirect.

- The non-transit factors; car park time and walk time took correct positive sign.

Figure 5.2.6

ACTIVITY CENTER PARAMETER ESTIMATES
Multinomial Model

Parameters	Linear S of P	Log Odds	Inferred Mode Use
TRANSIT FARE	-.015	-.016	-.016
c/SINGLE TRIP	26.000	26.200	21.600
TRANSIT WAIT TIME	-.054	-.059	-.093
Mins/SINGLE TRIP	4.500	4.700	4.700
TRANSIT CHANGE	.324	.346	.463
Direct/indirect	8.000	8.000	7.500
CAR PARK TIME	.045	.045	.067
MINS/SINGLE TRIP	4.800	4.500	4.900
WALK TIME	.059	.061	.086
MINS/SINGLE TRIP	13.200	12.800	12.400
WALK SP EXPERIMENT	-.008	-.009	-.049
CONSTANT	.200	.200	.600
NOT TRAVEL SP EXP.	.953	1.002	1.414
CONSTANT	20.600	20.300	18.300
CONSTANT	-.489	-.439	-.761
	2.600	2.200	2.700
R^2/Rho^2	.185	.184	.140
STANDARD ERROR	1.456	1.551	
N	6225	6225	6225

NOTES:-
Upper figure = Parameter Estimate
Lower figure = t value

Three constant terms were estimated.

- The overall constant applying to all three stated preference experiment design observations took negative sign.

- The "not travel" stated preference experiment constant which was specified to take a value of one if the respondent was administered that experiment also zero, took positive sign.

- The walk stated preference experiment constant estimate was negative but insignificant.

Together, the constants imply an unexplained preference away from transit by respondents of the car and walk stated preference experiments, and a strong preference towards transit for those who were administered the not travel stated preference experiment.

o High parameter significance for all the stated preference factors; only the walk stated preference experiment constant was insignificant at the 95% confidence level.

  - The 't' value for transit fare was approximately 26 (depending upon estimation technique) which was noticeably higher than in the Place of Work Survey.

  - The goodness of fit statistics were also higher than in the Place of Work Survey.

o Analysis technique affected the size of the parameter estimate. The ordering was:

  - Inferred Mode Use

  - Log Odds

  - Linear Strength of Preference.

The size difference varied by parameter estimate. The range in percentage difference between the Log Odds and Linear Strength of Preference factor estimates was 3% to 11%.

- The expected difference was 11%. Much of the discrepancy in the reported percentage differences may be attributed to parameter rounding to three significant figures.

o The Inferred Mode Use parameters were greater than the Log Odds parameters except in the case of the transit fare estimate, where the reported values were identical.

o Parameter significance was also affected by analysis technique: for transit fare, Log Odds analysis produced the parameter of highest significance (t=26) and Inferred Mode Use, the parameter of lowest significance (t=21.6).

(5) Tests of Reasonableness

As in the Place of Work Survey, tests were performed to assess the reasonableness of the parameters for:

o the implied elasticity of demand

o the implied values of time

o the ability of parameters on actual mode choice.

(6) Implied Elasticities of Demand

Figure 5.2.7 on the following page presents elasticity of demand measures for each factor estimated at the mean of the data series. The elasticities are representative elasticities as defined in Appendix B.

o The elasticity for direct service has not been computed because of its binary (0,1) specification.

o The mean probability of using transit (Pt) differed by analysis technique: Pt estimated using the Log Odds strength of preference conversion was 0.51 whereas Pt for the Inferred Mode Use conversion was 0.54. This difference accounts for the difference in elasticity measure -.764 compared to -.718 Log Odds:Inferred Mode Use. This difference is significant at approximately the 85% level (t=1.06). In contrast, the Linear Strength of Preference and Log

Figure 5.2.7

ELASTICITIES OF DEMAND
ACTIVITY CENTER

ELASTICITIES	FACTOR MEAN	UNWEIGHTED LINEAR S of P	UNWEIGHTED LOG ODDS	UNWEIGHTED INFERRED MODE USE
Transit fare,c/Single Trip	97.50	-.788	-.718	-.718
95% Confidence interval		.059	.057	.065
Non Transit walk time,mins	20.00	.636	.561	.791
95% Confidence interval		.094	.092	.125
Transit Wait time	7.50	-.582	-.543	-.856
95% Confidence interval		.095	.090	.134
Parking time,mins	7.50	.182	.155	.231
95% Confidence interval		.074	.072	.092

TRANSIT PROPORTIONS	LOG ODDS	INFERRED MODE USE
unweighted	.51	.54

Odds fare elasticities were much closer; more of the difference was due to rounding the parameters to three decimal places.

- The elasticity for non-transit walk time was of a similar magnitude (but opposite sign) to that of transit fare. For the Linear Strength of Preference and Log Odds models, the elasticity are lower than for fare whereas for the Inferred Mode Use model, the ordering was reversed.

- The other two elasticities were significantly lower:

    - Transit unit time was just over -.2 for the Linear Strength of Preference and Log Odds models and just over -.3 for the Inferred Mode Use model.

    - Parking time was just less than .2 for the Linear Strength of Preference and Log Odds models and just over .2 for the Inferred Mode Use model.

The precision of the elasticity estimates may be gauged from the 95% confidence interval also presented in Figure 5.2.7.

- This is interpreted as the means plus or minus the figure tabulated (the 95% confidence interval for the Linear Strength of Preference elasticity for transit fare is -.788 plus or minus .059).

    - The precision reflects the size of t value .9. Consequently, the transit fare elasticity is more precise than the non-walk time elasticity which is more precise than the transit wait time and car park time elasticities.

(7) Implied Values of Time

Figure 5.2.8 on the following page presents the values of time for the four time factors expressed in terms of transit fare.

Figure 5.2.8

VALUES OF TIME AND RELATIVE MONETARY VALUATIONS
ACTIVITY CENTER

Parameters	Linear S of P	Log Odds	Inferred Mode Use
Parking Time Value, c/hr	180	168	251
95% Confidence level	75	75	103
Wait Time Value, c/hr	216	221	348
95% Confidence level	95	94	149
Walk Time Value, c/hr	236	228	322
95% Confidence level	39	39	59
Direct Service Value, c/chg	21	21	28
95% Confidence level	6	6	8

- The Linear Strength of Preference and Log Odds values of time were close in mean estimate and 95% confidence interval but the Log Odds analysis produces noticeably higher mean estimates. For parking time, Log Odds analysis produced a mean value of time of 168c/hr, which was 83c/hour less than the Inferred Mode Use estimate of 251c/hr. The statistical confidence associated with the estimated difference was significant at the 85% confidence level (t=-/+ 1.3).

- Transit wait time and non transit walk time had similar values of around 255c/hour (Linear Strength of Preference, Log Odds) and 330c/hour (Inferred Mode Use).

- Parking time was valued lower at around 175c/hour (Linear Strength of Preference, Log Odds) and 250c/hour (Inferred Mode Use). The difference in wait and walk time versus parking time was significant at less than the 80% confidence level (t=.88).

- The valuation of direct service was approximately 21c per interchange (Linear Strength of Preference, Log Odds) and 28c (Inferred Mode U0e. This valuation seems reasonable; it coincides with the current surcharge levied on the Evanston express.

(8) Validation of Stated Preference parameters on actual mode choice.

Two separate validation exercises were performed:

- one on the car-transit stated preference data set; and

- one on the walk-transit data set.

Validation was not possible on the transit-not travel data owing to the absence of data on suppressed trips. The results of the validation exercise are presented in Figure 5.2.9 on the following page.

Figure 5.2.9

VALIDATION PARAMETERS

MODEL	CAR - TRANSIT		WALK - TRANSIT	
	CONSTANT	UTILITY DIFFERENCE	CONSTANT	UTILITY DIFFERENCE
Linear Strength of Preference	.45 (2.37)	.53 (2.76)	1.98 (2.14)	1.99 (2.30)
Log Odds	.46 (2.42)	.52 (3.00)	2.06 (3.32)	2.08 (2.40)
Inferred Mode Use	.48 (2.82)	.61 (2.60)	1.63 (2.91)	1.51 (1.50)
Logg Odds (Binary)	.44 (2.59)	.66 (1.89)	1.29 (2.58)	1.78 (2.00)
Number of Observations:	323		78	

Notes: Estimated as the probability of using transit
- (t) values in parenthesis: for constant (t) B=0;
- For utility difference (t) for B=1

Validation parameters are tabulated for the Multinomial Logit models estimated by Linear Strength of Preference, Log Odds and Inferred Mode Use techniques. Validation parameters for a fourth model - stated preference experiment specific parameters estimated by Log Odds are also tabulated.

Validation revealed:

- A significant and underestimation of the underlying preference for transit in both the car-transit and walk-transit data sets;
- Significant overestimation of the sensitivity to the utility difference between transit and car;
- Significant underestimation of the sensitivity to the utility difference between transit and walk.
    - The underestimation of the underlying preference for transit was common to both data sets. It is implied by the sign and significance of the estimated constant validation parameter. The estimated constant was positive with a /t/ value greater than two. The extent of underestimation was greatest in the walk-transit data set, with estimated constants greater than one.
    - The overestimation of the sensitivity to utility difference in the car-transit data set was implied by validation parameters less than one with /t/ values around, or in excess of, two.
    - The underestimation of the sensitivity to utility difference in the walk-transit data set was implied by validation parameters greater than one with /t/ values around, or in excess of, two.

The inability to replicate adequately actual mode choice was common to all four estimation techniques. Comparing the techniques reveals:

- The Log Odds binary technique estimated parameters which best replicate car-transit mode choice. These are reflected in a constant parameter closest to zero and a utility difference closest to unity (and insignificantly different from one, albeit marginally);

- The Inferred Mode Use technique and Log Odds binary techniques replicate choice similarly:

  - The Inferred Mode Use utility difference parameter was insignificantly different from one,

  - The Log Odds binary model produced a constant parameter which best fitted the actual underlying preference towards transit.

However, the validation exercise is not considered to be a strong test of the reasonableness of the estimated parameters especially the transit fare parameter.

- The transit utility functions comprised only two factors and the walk utility functions only one. Factors other than those within the Stated Preference experiment determine actual mode use.

- The cross-sectional variation in transit fare, the key variable of interest, was low: there was no noticeable difference between the transit fare perceived by car users and walkers and the actual fare stated by transit users. Figure 5.2.10 presents the mean and standard deviation of all the travel mode factors used in the validation exercise.

It is therefore not recommended that the validation parameters are applied to the transit fare estimates.

- Instead, it is recommended that the validation parameters relate more to those factors in which there are clear differences between the actual travel mode used and the rejected alternative travel mode used (for example transfer probability and non transit walk time).

Figure 5.2.10

MEAN FACTOR VALUES BY ACTUAL TRAVEL MODE AND SP EXPERIMENTS

FACTOR	CAR	TRANSIT	WALK	TRANSIT
Transit Fare (Cents)	110 (38.20)	111 (49.20)	94 (38.00)	99 (35.00)
Transfer Probability (ie. Direct/Transfer)	0.70 (0.45)	.52 (3.00)	-	-
Car Park Time (Minutes)	4 (5)	8 (10)	-	-
Transit Wait Time (Minutes)	-	-	36 (16)	16 (9)
N	164	159	49	30

Note: Standard error in Parenthesis

Figure 5.2.11

ACTIVITY CENTER MARKET SEGMENT PARAMETER ESTIMATES

LOG ODDS ANALYSIS

PARAMETERS	SP EXPERIMENT CAR	SP EXPERIMENT WALK	SP EXPERIMENT NOT TRAVEL	TRAVEL MODE CAR	TRAVEL MODE TRANSIT	TRAVEL MODE WALK	CAR AVAILABILITY AVAILABLE	CAR AVAILABILITY UNAVAILABLE	RACE BLACK	RACE WHITE	RACE OTHER
TRANSIT FARE	-.014	-.014	-.023	-.012	-.018	-.013	-.015	-.017	-.017	-.015	-.014
c/single trip	-17.200	-9.300	-21.100	-11.100	-23.400	-7.100	-21.400	-15.700	-18.600	-17.200	-7.100
t Mean Difference	.000		-5.041	4.535		2.728	1.551		-1.583		.506
TRANSIT WAIT TIME		-.086	-.038		-.050	-.083	-.063	-.054	-.050	-.055	-.101
mins/single trip		-4.700	-2.700		-3.400	-1.800	-3.400	-3.100	-2.300	-3.205	-2.800
t Mean Difference			2.073			-1.253	-.364		.180		-1.151
TRANSIT CHANGE	.386		.233	.360	.333		.393	.200	.282	.431	.310
direct/indirect	7.300		3.300	5.200	6.200		7.800	2.800	8.400	6.600	2.400
t Mean Difference				.308			1.982		-1.628		-.836
CAR PARK TIME	.046			.048	.043		.046	.047	.071	.026	.023
mins/single trip	4.300			3.500	3.000		4.200	1.800	4.800	2.400	.900
t Mean Difference				.252			-.035		2.048		-.031
NON TRANSIT WALK TIME		.041			.044	.071	.039	.044	.057	.065	.076
mins/single trip		13.300			5.700	13.100	9.369	9.290	6.400	10.310	3.800
t Mean Difference						2.863	-.536		-.733		.525
WALK SP EXPERIMENT					-.241		.007	-.150	.138	-.231	.836
CONSTANT					-2.900		.100	-1.400	3.500	-3.200	3.000
t Mean Difference							2.342		3.117		4.084
NOT TRAVEL SP EXPERIMENT					.550		.980	.893	1.124	.917	.987
CONSTANT					10.100		14.790	10.500	14.800	12.700	6.600
t Mean Difference							.105		1.931		.446
CONSTANT	.742	.019	3.309	.209	.739	-.454	-.845	-.202	-.850	-.510	.257
	6.300	.400	21.100	1.400	2.600	-1.600	-1.700	-.400	-1.300	-1.800	.500
t Mean Difference	2.701		12.207	-1.651		-2.970	-.570		.134		1.307
R²/Rho²	.086	.218	.256	.377	.184	.266	.155	.253	.200	.193	.236
STANDARD ERROR	1.639	1.495	1.297	1.576	1.491	1.410	1.589	1.415	1.525	1.530	1.440
N	3830	1060	1335	2080	3460	677	4659	1548	2594	2762	832

PARAMETERS	DESTINATION CBD	DESTINATION NON CBD	SEX MALE	SEX FEMALE	HOUSEHOLD INCOME <$30K	HOUSEHOLD INCOME >$30K	AGE <18 Y.O.	AGE 18-65	AGE >65 Y.O.	DISTANCE <2 MI	DISTANCE 2-6 MI	DISTANCE >6 MI
TRANSIT FARE	-.017	-.015	-.018	-.025	-.026	-.015	-.013	-.016	-.014	-.013	-.016	-.016
c/single trip	-17.700	-19.600	-17.100	-19.220	-21.200	-14.900	-5.100	-24.200	-1.400	-9.710	-18.602	-15.850
t Mean Difference	-1.629		-2.343		-.795		1.284		.000	1.995		.252
TRANSIT WAIT TIME	-.047	-.067	-.035	-.072	-.055	-.059	-.134	-.055	-.032	-.097	.059	.033
mins/single trip	-2.300	-4.200	-1.600	-4.508	-1.700	-2.300	-3.300	-3.800	-1.000	-4.465	7.167	1.302
t Mean Difference	.771		1.365		.135		-1.154		.695	-6.704		-.989
TRANSIT CHANGE	.442	.287	.355	.341	.300	.400	.465	.338	.403	.342	.329	.364
direct/indirect	6.300	5.300	5.100	6.120	5.400	5.600	2.700	7.290	2.800	2.513	9.248	5.419
t Mean Difference	1.749		.157		-1.105		.711		.429	.112		.626
CAR PARK TIME	.023	.058	.039	.050	.057	.035	.036	.047	-.003	.055	.053	.036
mins/single trip	1.400	4.700	2.400	3.880	4.400	2.200	2.400	4.400	-.100	1.782	3.601	2.348
t Mean Difference	-1.703		-.526		1.073		1.188		-1.570	.071		-.822
NON TRANSIT WALK TIME	.077	.054	.058	.098	.054	.075	.051	.063	.057	.066	.059	.033
mins/single trip	9.000	9.300	4.900	3.100	9.800	8.000	3.700	11.500	4.290	10.843	7.167	1.302
t Mean Difference	2.239		.000		-1.931		-.839		-.410	.543		-.989
WALK SP EXPERIMENT	-.518	.233	-.182	.040	-.225	.204	-.338	.081	-.285	-.243	.155	-.544
CONSTANT	-5.400	3.600	-2.000	.980	-2.000	2.000	-1.900	1.300	-2.300	-1.861	1.730	-2.152
t Mean Difference	-6.490		-2.145		-2.750		-1.227		-2.609	-2.291		-2.606
NOT TRAVEL SP EXPERIMENT	.848	1.090	.859	1.062	.940	1.210	1.053	1.102	.518	.279	1.205	.303
CONSTANT	11.230	14.700	10.500	14.800	15.800	12.900	5.700	19.900	1.600	1.746	17.714	11.262
t Mean Difference	-2.471		-1.963		-2.811		-.254		-1.781	-5.339		-2.872
CONSTANT	-.565	-.807	-.203	-.437	-.261	-1.000	-.163	-.542	-.072	-.444	-.531	.418
	-1.700	-1.700	-.600	-1.700	-1.100	-2.500	-.300	-2.600	-.300	-1.237	-1.611	.527
t Mean Difference	-.386		.551		1.519		.444		.623	.149		1.118
R²/Rho²	.216	.171	.186	.180	.193	.173	.227	.189	.170	.172	.213	.157
STANDARD ERROR	1.552	1.540	1.550	1.548	1.500	1.616	1.409	1.551	1.531	1.526	[illegible]	1.581
N	2299	3926	2286	3758	3740	2326	401	5163	593	1175	722	2260

NOTES:-

* Upper figure = parameter estimate.
Middle figure = parameter t value.
Lower figure = t value for difference in mean estimates.

** Base group for difference in triple segments is central one,
ie B(Black)-B(White);B(Other)-B(White).
Other segments, first column mean - second column mean.

(6) Market Segment Parameter Estimation

Figure 5.2.11 presents market segment parameter estimates, parameter t values and t values associated with the difference in estimate between pairs of market segments. Observations have been segmented by:

- Stated Preference experiment (car, walk, not travel)
- Travel mode (car, transit, walk)
- Car availability (available, unavailable)
- Race (black, white, other)
- Destination (CBD, non CBD
- Sex (male, female)
- Household income (<$30,000, >$30,000)
- Age (<18, 18-65, >65

All parameters presented in Figure 5.2.11 have been estimated by Log Odds analysis. The key findings were:

o Stated Preference experiment - those administered the not-travel Stated Preference experiment were more sensitive to changes in all factors especially transit fare and to have a greater unexplained preference towards transit.

o Travel mode - car users and walkers were less sensitive to transit fare than transit users. Walkers were more sensitive to walk time than transit users. Walkers had a greater unexplained preference towards walk; transit users a greater unexplained preference towards transit. Car users had no significant unexplained preference towards car or transit.

o Car availability - no significant effects.

o Race - Blacks were more sensitive to changes in car park time than whites. Whites had a greater unexplained preference towards walking.

- Destination - travelers to the CBD were less sensitive to transit fare and non-transit walk time than those traveling to the non CBD, and had a greater unexplained preference towards transit.

- Sex - males were more sensitive to transit fare than females and had a greater unexplained preference away from transit towards walk and not travel.

- Income - wealthier households (income >$30,000) were more sensitive to changes in non-transit walk time, and had a greater unexplained preference from walk and towards not travel.

- Age - young and old had a greater unexplained preference towards walk than 'middle' aged respondents (18-65). Old respondents also had a greater unexplained preference towards not travel.

- Distance - sensitivity to transit fare was lower at distances under 2 miles but transit wait time was higher. The unexplained preferences were significantly different by distance segment.

These results correspond to the results of the Analysis of Mean. However, the disaggregate estimation presented here allowed the differences by market segment to be established with greater accuracy. The sensitivity to transit fare, the focus of interest in this study, varied by market segment.

- Market segmentation highlighted greater sensitivity among:

  - Transit users particularly those whose SBA was not travel;

  - Travelers to non CBD destinations;

  - Respondents traveling over 2 miles.

3. CONCLUSIONS

The Stated Preference experimental design and distribution method worked well. A mode split model was estimated enabling forecasts to be made of the diversion to (or from) transit from other mode following changes in transit fare and/or other factors.

- o The data collected at activity centers, related to non-work journeys. Car and transit were both treated as composite modes.

- o The Stated Preference experiments were administered by trained interviewers. This allowed the Stated Preference experiment to:

  - Be tailored to the travel alternatives available to the interviewee; and

  - Reduce the scope for self-selection and misunderstandingof terminology. Survey methods based on self-completion carry an inherent work of bias arising from those respondents who are particularly concerned about public transit responding at a higher rate than average. This explains why car users were under represented in the Place of Work Survey.

It also enabled those respondents who had never used CTA services to be filtered out.

Three Stated Preference experimental designs were developed.

- o Each featured a pairwise comparison of transit with a specified travel alternative; car, walk or not travel. The interviewer determined the Stated Preference experiment to be administered according to the actual travel mode used to the activity center. If this was transit, the stated second best alternative of the respondent was used.

- o The response to the filter questions was analyzed to identify the significant socio-economic and journey profile characteristics determining response.

- The analysis of past usage of CTA was specified as a dichotomous dependent variable (1 if used CTA; 2 if never used CTA). The analysis revealed that the individuals most likely to use CTA services have the following characteristics:

  - Female;
  - Low household income;
  - Small household size;
  - Low car availability.

- The analysis of transit users/ Second Best Alternative used a polychotomous dependent variable (1 if car; 2 if walk; 3 if not travel). The analysis revealed that those individuals most likely to select car as their SBA have the following characteristics:

  - Less than 65 years old;
  - White;
  - Traveling to a CBD destination;
  - Household income between $10k and $30k;
  - High household car availability.

  and those individuals most likely to select walk have the following characteristics:

  - Making short trips;
  - Aged under 65;
  - Black;
  - From large households;
  - With high household car availability.

- Each Stated Preference experiment was tailored to address the characteristics considered important in each of the three pairwise comparisons.

- All three Stated Preference experiments featured three factors and apart from transit fare, different factors featured in each Stated Preference experiment.

Over all three experiments, five factors were featured:

- Transit fare;
- Transit wait time;
- Transit direct service;
- Non-transit walk time;
- Car parking time.

The presence of transit in all three comparisons allowed a multinomial model to be estimated in which the data from all three Stated Preference experiments were combined.

- o This was undertaken in addition to binary models in which each Stated Preference experiment was analyzed separately.

Three different disaggregate analysis techniques were used to estimate demand quantities.

- o The estimated transit fare parameter differed little by analysis technique.

- o Log Odds analysis produced a more efficient estimator than either the Linear Strength of Preference analysis or Inferred Mode Use analysis.

- o Analysis found transit fare to be the most important of the Stated Preference factors. Transit direct service and non-transit walk time emerged as the second most important factors with carpark time and transit wait time the least important. All five factors were estimated with high precision, reflected in 't' values in excess of four.

The tests of reasonableness were applied to the estimated parameters:

- o Implied elasticities of demand;

- o Implied values of time;

- o Ability to replicate observed mode choice.

These tests suggested the estimated parameters to be reasonable both in terms of the estimated mean value and the confidence range of estimate.

- The demand elasticity with respect to transit fare estimated at the mean of the data set by Log Odds analysis was -.7 plus or minus .06. This is reasonable given the discretionary nature of the trips surveyed and the high level of availability of travel alternatives.

- This value reduces to -0.6 if the actual average CTA fare of 83 cents is assumed rather than the survey data set mean. Previous research based on other transit properties suggest off-peak elasticities to be in the range -0.4 +/- 0.26 (Quoted in "Patronage Impacts of Changes in Transit Fares and Services by Ecosometrics, 1980). This indicates that the Activity Center Survey value of fares elasticity to be towards the upper end of the expected range.

Values of time differed by time component, and to a lesser extent by estimation technique.

- Inferred Mode Use analysis produced the highest valuations although no estimate was significantly higher than the Log Odds or Linear Strength of Preference analyses at the 95% confidence level.

- Transit wait time and non-transit walk time were valued similarly at around $2.20/hour while parking time was valued at around $1.70/hour (Log Odds estimate).

- The transit direct service parameter estimate implied that individuals valued the benefit of a direct service at around 20 cents above an indirect service.

The validation exercise revealed:

- A significant underestimation of the underlying preference for transit in both the car-transit and walk-transit data bases;

- A significant over estimation of the sensitivity to the utility difference between transit and car; and,

- A significant underestimation of the sensitivity to the utility difference between transit and walk.

However, the validation exercise was not considered a strong test of reasonableness of the parameters especially with respect to transit fare.

- There was no noticeable difference between the transit fare as perceived by car users and walkers and the actual fare paid by transit users.

- Consequently, it is not recommended that the validation parameters be applied to the transit fare parameter estimates.

The data base showed different segmentations of response to be assessed. The sensitivity to transit fare was found to be greatest for:

- Transit users especially those whose second best alternative was not to travel;

- Travelers to the CBD;

- Respondents traveling over 2 miles;

- Males

In conclusion, the survey is considered to have been successful. The sensitivity to transit fare and other travel mode factors was established in aggregate and by market segment. Additionally, useful information on user profile, travel mode perceptions and values of travel time have been established.

VI. COMPARISION OF PLACE OF WORK AND ACTIVITY CENTER SURVEY RESULTS

SECTION VI.
COMPARISON OF PLACE OF WORK AND ACTIVITY CENTER RESULTS

The Place of Work and Activity Center Surveys were compared in terms of both the nature of the samples and the parameters estimated. There are traditional preconceptions regarding both the structure and behavior of different transit markets; such a comparison of the CTA surveys would help to put them into a broader context.

1. SURVEY DESCRIPTORS

(1) Household Size

Household size was slightly higher on average in the Activity Center Survey (3.3 vs 3.0, Activity Center : Place of Work).

- There were more Place of Work respondents in two person households and more Activity Center respondents in 5+ households.
- It would be reasonable that 2 person households where both are working should be over represented in the Place of Work and underepresented in the Activity Center survey.

(2) Age Profile

Age distributions were not radically different between the surveys; mean values were as follows:

Mode	Place of Work	Activity Center
Auto.	37	36
Transit	35	34

Activity Center respondents were slightly younger in both the auto and transit categories but this survey was dominated by the young adult (18-34) group.

- o The Place of Work Survey was more evenly spread over age groups.

(3) Household Income

The Place of Work respondents claimed a higher household income that those in the Activity Center Survey. Averages were as follows:

Mode	Place of Work	Activity Center
Auto.	39,000	32,000
Transit	33,000	27,000

- o Part of the difference might be explained by the accuracy of perception between the main earner (at the Place of Work) and the rest of the family (at the Activity Center).

- o In both auto and transit categories the Activity Center Survey appeared to have more people in the lowest income groups.

(4) Sex Profile

There were no significant differences in the sex profiles between the two surveys.

	Place of Work	Activity Center
Auto: Male	39	45
: Female	61	55
Transit: Male	39	36
: Female	61	64

The proportion of females in the Activity Center Survey was slightly lower for auto users and slightly higher for transit users.

(5) Race Profile

In the most numerous categories, (white and black), there were considerable differences between the surveys. This was particularly true among the auto users: the Place of Work Survey found 67% were white compared with only 42% in the Activity Center Survey.

	Auto		Transit	
	Place of Work	Activity Center	Place of Work	Activity Center
White	67	42	57	46
Black	23	45	32	43
Hispanic	5	9	5	8
Asian	3	2	4	1
Native Am.	0	0	1	0
Other	2	4	2	2
	100	100	100	100

- o The difference was less marked among transit users where the relative proportions of white people were 57% (Place of Work), 46% (Activity Center).

- o Conversely, there was a higher proportion of black people in the Activity Center Survey.

The proportions of white and black in the Place of Work Survey were quite close to the 1980 Journey to Work survey results.

- o No source exists with which to validate the Activity Center distribution by race.

  - If the recent survey was reasonably unbiased, off peak travel is split evenly between white and black people with other races making up the remaining 10%.

2. PARAMETER ESTIMATES

The Place of Work and Activity Center Surveys were successful in estimating transit fare parameters through Stated Preference questions. Although similar, the Stated Preference experimental designs featured in the two surveys differed in detailed design.

- The Place of Work design was simpler, featuring a comparison between car and transit, where transit was treated as a composite mode including bus and train.
- These two modes dominated the journey to work travel market, where suppression and generation of trips was irrelevant. This made a simple two mode experimental design possible and one which could be administered impersonally, by self-completion mail-back questionnaire.
- The Activity Center Survey needed to be more complex, as walk is an important travel alternative for off peak travel.
  - The discretionary nature of travel meant that suppression and generation of trips was important.
  - Three Stated Preference experimental designs were developed to respond to the three main travel alternatives to transit: car, walk and not travel.
  - This added complexity could not be addressed adequately with self-completion mail-back questionnaires.
- A more expensive interviewer-led method was adopted.
  - Interviews were conducted at activity centers across Chicago with fieldworkers determining the most appropriate Stated Preference experiment to administer on the response of individuals to two initial filter questions.

- o Of the two surveys, the Place of Work achieved the largest data base: in excess of 8000 data observations (over 1000 respondents) compared to around 6250 (around 780 respondents) in the Activity Center Survey.

  - Share analysis techniques were used to explain the response to the surveys and binary models fitted.

- o The Activity Center Survey comprised three Stated Preference experiments, which provided the opportunity of performing either:

  - Separate analyses/grouping response by Stated Preference experiment or,

  - Aggregating response to form a grand data set and analyzing the response to all three Stated Preference experiments simultaneously.

In the case of the Place of Work data base it was possible to weight responses to adjust for differences in response by travel mode and market segment, compared to journey to work figures for Chicago as a whole.

- o Aggregate and disaggregate techniques were applied to both survey data bases.

  - An aggregate analysis involving the graphical presentation of the mean strength of preference response of all respondents (or controlled for socio-economic and trip profile) provided a preliminary interrogation of the data bases.

  - Three disaggregate techniques differing in terms of the conversion of the Strength of Preference response to the Stated Preference questions and in terms of estimation method were then used to derive demand parameters.

- The list of factors were not the same in the two surveys: comparison is limited to the common factors:

  - Transit fare, walk/wait time and

  - Car park time.

- A straightforward comparison of the walk/wait time and car park time estimates is possible because the same units (mins./single trip) were used.

- The units used to describe the transit fare were different.

  - In the Place of Work Survey transit fare was specified in dollars/month whereas in the Activity Center Survey it was specified in cents/single trip.

  - To compare the estimates, the Place of Work estimate was standardized by assuming 40 single trips per month. Figure 6.1 enables comparison of the estimates:

Figure 6.1

Comparison of Estimates
Place of Work and Activity Center Surveys

	Place of Work	Activity Center	Difference* (¦AC¦-¦PW¦)
Transit Fare	-.01 (13.6)	-.016 (26.2)	.006 (6.3)
Walk/Wait Time	-.014 (1.8)	-.059 (4.7)	.045 (3.0)
Car Park Time	.015 (2.0)	.045 (4.5)	.03 (2.4)

Notes: ¦t¦ value in parenthesis
Parameters estimated by Log Odds Analysis.
Weighted parameters tabulated for Place of Work Survey.
* Independent of sign

- The Place of Work Survey produced significantly lower estimates (ignoring sign) than the Activity Center Survey.
  - These results imply commuters to be less sensitive to changes in transit fare than leisure travelers: a finding in agreement with many other urban travel demand studies.
- The Place of Work Survey produced less efficient estimators than the Activity Center Survey. Parameter ¦t¦ values were less than half those in the Activity Center Survey.

- This resulted from lower intra-personal response variation to the eight Stated Preference questions, which in turn, resulted from a lower sensitivity to each factor associated with greater 'inertia' favoring the respondent's current mode of travel.

o The results presented in Figure 6.1 were produced by Log Odds analysis. The other two disaggregate techniques Linear Strength of Preference and Inferred Mode Use produced very similar parameter estimates.

- In terms of efficiency, Inferred Mode Use analysis produced parameters with lower |t| values resulting from the grouping of weak and strong preferences causing a reduced fit between preference and travel factors.

Three tests of reasonableness were applied to the Place of Work and Activity Center estimates:

- Implied elasticity of demand

- Implied values of time

- Ability to replicate observe mode choices

Figure 6.2 presents the elasticities of demand with respect to the three comparable factors in the Place of Work and Activity Center surveys.

o Mode share elasticities are non constant.

In Figure 6.2, they have been estimated at the mean of the respective Stated Preference databases. As such, they reflect the mean probability of using transit and the mean value of the factor in the Stated Preference experimental design.

Figure 6.2

Comparison of Elasticities
Place of Work and Activity Center Surveys

	Place of Work	Activity Center	Difference (¦AC¦-¦PW¦)
Transit Fare	-.87 (.13)	-.72 (.06)	-.15 [2.1]
Walk/Wait Time	-.65 (.71)	-.54 (.09)	-.11 [.3]
Car Park Time	.06 (.06)	.16 (.07)	.1 [2.2]
Base probability of using transit	.38	.51	

Notes: ( ) 95% confidence range;
[ ] ¦t¦ value for Ho ¦AC¦ = ¦PW¦;
Parameters estimated by Log Odds analysis.
Weighted parameters tabulated for Place of Work Survey.

The figure shows the Place of Work transit fare elasticity to be higher than its Activity Center counterpart: a result of a lower base market share overriding a lower sensitivity parameter.

- This result conflicts with a priori expectations. It was expected that the ordering would have been reversed: a higher Activity Center elasticity.

- o However, it is difficult to make this sort of comparison because the valued of elasticity depend so much on both the base and average fare and the base probability of using transit.

  - The base probability of using transit should be very much higher for work trips compared to non-work, whereas this survey data shows the opposite.

  - In addition, the average fare used in the Place of Work Survey design was 65% above actual CTA fare compared with 19% for the Activity Center Survey design.

  - Both these factors explain the apparent reversal in the expected relative values for fare elasticity.

- o In the Activity Center Survey, the estimate were unweighted, although the sampling methodology ensured less bias in response by actual travel mode than the Place of Work Survey. In the Place of Work Survey, self-selection may have inflated the fare elasticity. Those car users who were more likely to transfer to transit may have been more inclined to complete and return the questionnaires than those less likely to transfer.

Figure 6.3 presents the valuations of parking time and wait time expressed in terms of transit fare for the Place of Work and Activity Center Surveys.

Figure 6.3

Values of Parking and Transit Wait Time
Comparison of Place of Work and
Activity Center Estimates

(cents per hour)

	Place of Work	Activity Center	Difference AC - PW
Parking Time	90 (20)	168 (75)	78 [2.0]
Transit Wait Time	84 (93)	221 (94)	137 [2.1]

Notes:
( ) 95% confidence range
[ ] |t| for Ho: Place of Work = Activity Center Log Odds Estimates

Activity Center produced higher mean valuations, the difference marginally significant at the 95% confidence level.

Figure 6.4 presents a comparison of the results of the validation exercises.

Figure 6.4

COMPARISON OF VALIDATION PARAMETERS

	Place of Work	Activity Center[1] Car Transit	Activity Center[1] Walk Transit
Constant	1.2 (15.5)	.44 (2.59)	1.29 (2.58)
Utility Difference	.92 (.9)	.66 (1.89)	1.78 (2.0)

Note: |t| values in parenthesis : Ho for constant B = Ho for utility difference B = 1.

(1) Binary Log Odds Estimate Tabulated

In both surveys, the underlying preference for transit was underestimated. This was reflected in significant positive validation constants.

- o The utility difference calculated on the Stated Preference parameters and the estimated times and costs of chosen and rejected travel modes for the Place of Work respondents replicated actual travel mode choice reasonably closely : the validation parameter was insignificantly different from one.

In contrast, validation of the Activity Center Survey parameters revealed the sensitivity to car-transit time/cost differences to be overestimated, while underestimated for walk-transit time/cost differences. However, the significance was only marginal at the 95% confidence level.

The large data bases allowed response to be segmented according to the socio-economic profile of the respondent.

Figure 6.5 compares the differences in sensitivity to transit fare by market segment in the Place of Work and the Activity Center Surveys.

Figure 6.5

COMPARISON OF SENSITIVITY TO TRANSIT FARE
BY MARKET SEGMENT

SEGMENTATION	PLACE OF WORK	ACTIVITY CENTER
SEX: Males/Females	0	+
INCOME: <$30K/>30K	0	0
AGE:		
- <18/18-65	NE	0
- >65/18-65	NE	0
RACE: Non-Whites/Whites	0	0
STATED PREFERENCE EXPERIMENT:		
- Car Transit/Walk-Transit	NA	0
- Not travel-Transit/ - Walk-Transit	NA	+
TRAVEL MODE:		
- Transit/Car	+	+
- Transit/Walk	NA	+
CAR AVAILABILITY:		
- Unavailable/Available	+	0
DESTINATION:		
- Non-CBD/CBD	+	+
DISTANCE:		
- <2mls./2-6mls.	0	+
- >6mls./2-6mls.	0	0

Key:
- 0 — Market segments not significantly different at 95% confidence level;
- \+ — First group (eg, males) more sensitive than second group (eg, females);
- NA — Not Applicable;
- NE — Not Estimated

Note: Logs Odds Estimates

Both surveys found transit users to be more sensitive to changes in transit fare than non transit users and travelers to the CBD to be more sensitive than travelers to non CBD destinations. The surveys differed in the significance attached to sensitivity differences between other market segmentations.

- The Activity Center Survey found males to be significantly more sensitive to changes in transit fare than females, whereas the Place of Work Survey found the difference to be insignificant.

In conclusion, both surveys achieved their primary objective; the provision of transit fare demand parameters.

- Tests of reasonableness were applied and the demand parameters segmented by market.

- Comparing the different distribution methods, the self-completion method used in the Place of Work Survey provided data at a low cost per questionnaire.

- The interviewer led method used in the Activity Center Survey provided a control over sample representivity and enabled questioning to be closely tailored to the socio-economic and journey purpose profiles of the interviewee.

APPENDIX A

i. Survey of Route 94

ii. Place of Work Survey

iii. Activity Center Survey

APPENDIX A(i)

SURVEY OF ROUTE 94

The primary aim of the survey was to establish transport alternatives to using the bus. This information was required to aid the design of a trade-off survey which would ask riders to state their preference between pairs of alternative travel modes.

- o The presentation of meaningful alternatives would be vital to the design of the trade off survey.

A secondary aim was to explore the possibilities of using self-completion questionnaires on buses and the kind of data which could be collected using this technique.

- o In addition, it provided an opportunity to measure the length of ride of bus passengers.

1. SURVEY PLANNING AND IMPLEMENTATION

Route 94 was selected because it is a reasonably long route running through a broad range of different neighborhoods. It could therefore provide a good trial of the methodology to assess its applicability to other routes. The time was selected because the survey could commence in the off peak period thereby allowing the staff to get used to the survey method before the evening peak which was likely to be more difficult given the heavy loadings on the route.

2. SURVEY QUESTIONNAIRE

The questionnaire is shown in Figure 1 following this page. This was printed on a card measuring approximately 3.5" x 7" so that it could be easily held in one hand.

- o A list of information which the questionnaire was designed to collect is shown in Annex 1.

FIGURE 1

ON-BUS SURVEY QUESTIONNAIRE CARD

cta

BUS SERVICES SURVEY

Please hand in this card **when you get off the bus.**

№ 000003 6

For Office Use

A. Where are you coming from?
(Check one)
☐ Home ☐ Shopping ☐ Other
☐ Work ☐ School
Where was this? (street intersection)
_______________ and _______________
☐ 7
☐☐☐ 10

B. Where are you going to?
(Check one)
☐ Home ☐ Shopping ☐ Other
☐ Work ☐ School
Where is this? (street intersection)
_______________ and _______________
☐ 11
☐☐☐ 14

C. How did you get to the bus stop?
☐ Walk ☐ Bus ☐ Train ☐ Other
☐ 15

D. How will you get to your destination when you get off this bus?
☐ Walk ☐ Bus ☐ Train ☐ Other
☐ 16

E. If you had not used bus, how else could you have reached your destination?
☐ Driven automobile
☐ Got a ride in automobile
☐ Walked all the way
☐ Not made the trip
☐ Other, please specify _______________
☐ 17

F. How often do you make a trip like this?
__________ times per month
☐☐ 19

G. Did you have an automobile available for this trip?
☐ Yes ☐ No
☐ 20

H. If yes, why did you not use it? _______________
☐ 21

I. Please give fare type.
☐ Full Cash ☐ Reduced Cash ☐ Pass
☐ 22

J. Please indicate your age, sex and occupation.
☐ Under 18 ☐ 35-44 ☐ Male
☐ 18-24 ☐ 45-64 ☐ Female
☐ 25-34 ☐ 65 +
Occupation _______________
☐☐☐ 25

K. Would you be willing to be interviewed about your use of buses? If so, please give your Phone No./Address.

____
Phone No. Address

THANK YOU FOR YOUR HELP.
☐☐ 27

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3. SURVEY METHOD

The survey method is also described in Annex 1.

The survey was carried out on Monday 13 April 1987 by two teams of two people. Both started from the north end of Route 94 near Chicago Avenue at mid-day and traveled south to Marquette. The teams completed eleven runs and finished the survey at 6.30 pm having distributed 360 questionnaire cards.

- The survey method worked reasonably well as a pilot exercise.

- Little difficulty was encountered in identifying route sections or in keeping track of the distribution and collection of cards.

- However, problems were encountered in persuading passengers to accept a card as they boarded the bus, particularly riders who were only traveling a short distance. This could lead to bias against short riders in the survey results.

  - Many passengers attempted to return the questionnaire to the survey staff as soon as they had been completed, but this was solved by asking them where they intended to get off the bus and marking the card accordingly.

4. ANALYSIS OF RESULTS

The primary aim of the survey was to determine transport alternatives to using the bus.

The responses were as follows:

Car driver	22%
Car passenger	28%
Walk	16%
Not travel	21%
Other	4%
Non Response	9%

It is significant that such a large proportion - 21% stated that they would not have traveled if the bus service was not available.

- There are problems in interpreting this response as each individual will interpret this question differently.

- It does however give an indication of the more important travel options.

  - It is significant that 28% of respondents gave car passengers as an alternative; unfortunately, this is difficult to treat adequately in demand models since there is no easy way to establish its availability in terms of cost or convenience.

  - It also implies that riders who come from non car-owning households cannot be assumed to be a captive market.

(1) Number of Riders Giving Walk as Alternative

As a check on validity, a tabulation of distance was derived:-

No. of stages:	1	2	3	4	5	6	7	8	9	10	11
No of riders giving walk as an alternative to bus:	2	17	15	6	3	1	0	1	3	0	1

Mean = 3.5

As the table shows, 88% of respondents who cited walk as an alternative, traveled 5 stages - roughly 2.5 miles.

- The average journey was 3.5 stages - 1.75 miles.

- This distance is very similar to that which respondents gave during the Activity Center Survey - 1.8 miles (see Figure 2).

(2) Average Trip Length

One of the advantages of this survey method, is that the length of ride can be established by noting when the card was issued and collected, even if the questionnaire is not completed by a passenger.

Figure 2 shows the distribution of the number of stages traveled by respondents; an average of 4.8 stops or about 2.4 miles.

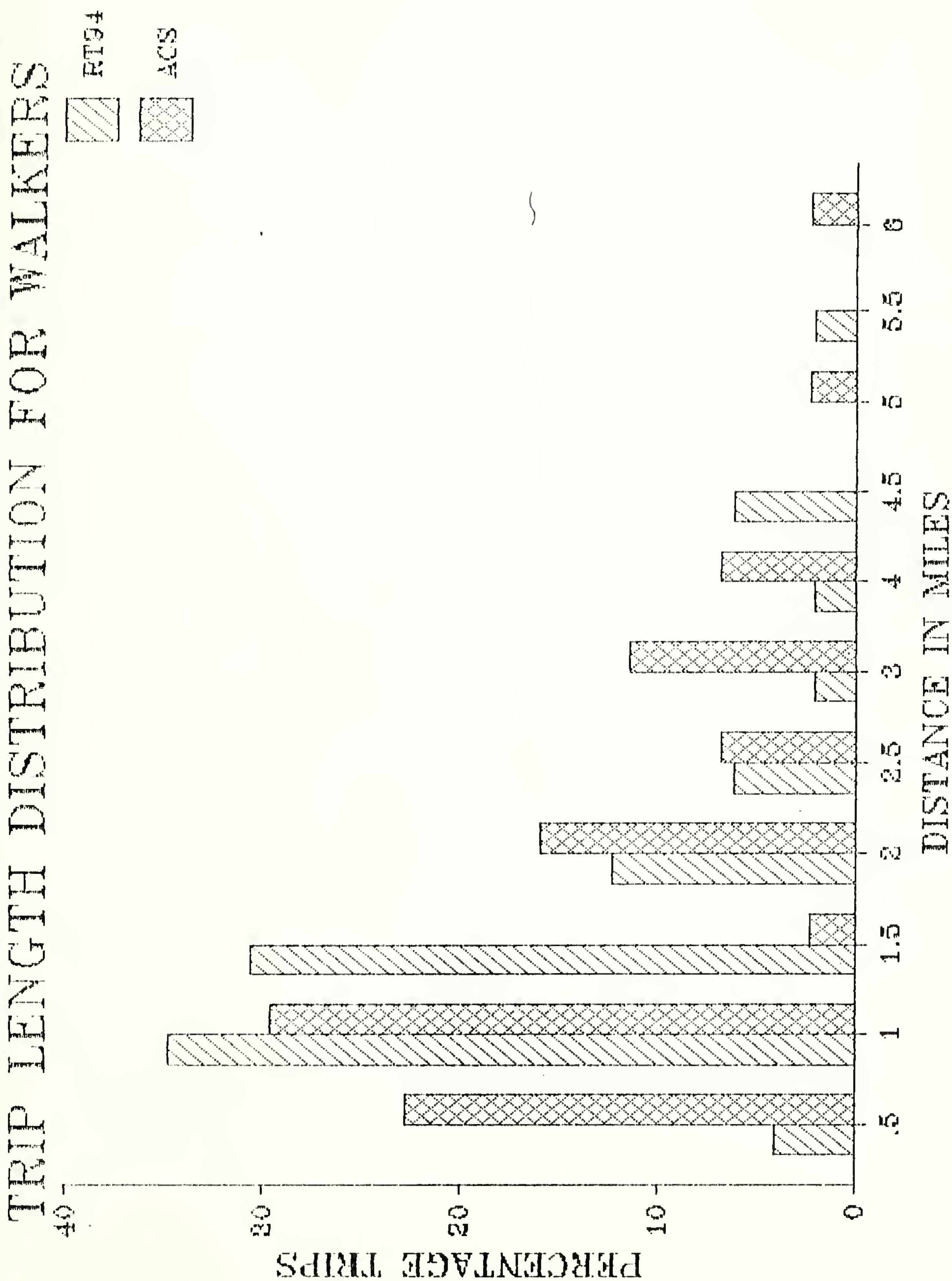
- o There is no current source of alternative information against which this can be judged.
- o The average non CBD journey length derived from the 1979 O and D survey was 4.1 including all bus rides and walking distance at either end.
- o The Trip Component Survey estimated the number of stages per journey to be around 1.5. This would therefore imply an average stage length for 1979 OD Survey of 2.7 miles which is reasonably consistent with the results of this survey.

(3) Response Rate by Question

Of all cards distributed, 13% were either not completed or were deemed insufficiently complete to be worth coding. Of those coded the percentage response rate by question was as follows:

A	Where are you coming from?	92%
B	Where are you going to?	92%
C	Mode to stop	95%
D	Mode from stop	93%
E	Alternative Modes	91%
F	Journey frequency	78%
G	Auto availability	90%

FIGURE 2


TRIP LENGTH DISTRIBUTION FOR WALKERS
FT94
ACS
PERCENTAGE TRIPS
40
30
20
10
0
.5
1
1.5
2
2.5
3
4
4.5
5
5.5
6
DISTANCE IN MILES

H	Reason auto not used	not coded
I	Fare type	91%
J	Age	87%
H	Sex	60%
I	Occupation	not coded

Notes:

- The location of the origins and destinations given by riders were not coded.
- About 50% of all questionnaires completed had given the street intersection.
- Of the remaining questions, question F was least reliable as it appeared that there was lack of understanding of "a trip". It was obvious that a trip was taken to mean both a one way ride and a return journey. The question should have been rephrased to read "How many times per month do you make a trip to ......" (give destination as indicated in Question B.)

(4) Journey Purpose

	Percentage of Trips	
	By origin	By destination
Home	31	53
Work	38	13
Shopping	4	6
School	5	3
Other	14	17
Missing	8	8

Traveling from work and to home are the most common journeys, reflecting that the survey period covered the evening peak.

- The "other" category is significantly large; it would have been interesting to gain more data on the other kinds of journey purpose riders would have given.

- It is clear that the question should have been rephrased to read "Other. Please specify..". The fact that schools were on holiday on the day of the survey is reflected in the low proportion of school trips.

(5) Access to and from Bus Stop

The table below shows how passengers get to and from the survey route bus stops.

	Walk	Bus	Train	Other	Total
Walk	131	57	11	1	200
Bus	39	20	1	0	60
Train	20	5	0	0	25
Other	2	1	1	0	4
Total	192	83	13	1	289

- 46% of all journeys surveyed were single stage ie had walk or other mode at both ends of the ride.

- 44% of journeys were at least two stage and 9% at least three stage.

- Assuming that no other CTA rides were involved other than those mentioned in the survey, the average number of unlinked trips per journey was 1.63 which is consistent with the findings of the Trip Component Survey undertaken by CTA in November 1986 (1.58).

(6) Car Availability

18% of respondents stated that they did not have a car as an alternative source of transport.

- To check for consistency, a cross tabulation of the 22% who said that they did have the choice of driving a car against the 22% who said that a car was available for the trip was computed.

Car available ->	Car not available ->
46% ->	54% ->

This demonstrates the difficulty in establishing the true meaning of car availability.

(7) Fare Type

	Survey	GFI
Full fare	52%	48%
Reduced fare	12%	19%
Pass	27%	33%
Missing values	9%	-

To test the hypothesis that riders with a pass are more likely to make multi-stage journeys, a cross tabulation of single stage journeys against fare type was derived.

- o The results of this analysis showed that there was no significant difference (ie 2 percentage points) between pass and cash fare journeys.

Age	%
1	11
18-24	21
25-34	25
35-44	12
45-64	12
65+	6
Missing Value	13

Sex	
Male	21%
Female	38%
Missing Value	41%

3. CONCLUSIONS

Overall, the survey achieved its aims and provided the information required for the design of the Stated Preference Surveys.

- On the basis of these results, it was decided that for the off-peak non-work journey, it would not be possible to undertake a single two-way trade-off survey involving a simple binary choice of transport modes.

- It was determined that a meaningful trade-off would have to be established for each respondent and that an appropriate trade-off questionnaire would have to be completed.

    - This implied the need for a range of different questionnaires to cover the different situations.

The Place of Work Survey was undertaken using self completion questionnaires distributed at Places of Work. The Activity Center surveys were conducted by interview techniques.

ANNEX 1

ON-BUS CARD QUESTIONNAIRE SURVEY

INSTRUCTIONS FOR SURVEY STAFF

1. DESCRIPTION OF METHOD

The aim of the survey is to collect information on the pattern of travel made by riders using CTA bus services. The items of information to be collected are:

1. Address from where journey started
2. Address where journey will end
3. Stop at which rider boarded the bus
4. Stop at which rider got off the bus
5. Other modes in addition to the bus being surveyed used by riders to travel between 1. and 2. above
6. Journey frequency
7. Journey purpose
8. Fare type
9. What alternatives riders had to making their journey by public transport. This is aimed at alternatives such as getting a ride with a friend, walking, taking their car but also options like not making the journey or making the journey at some other time when transport is available. Riders may give train as an alternative but if possible we want them to provide information about alternatives to public transport.

10. Whether the rider had a car available for that particular journey, i.e., chose to take the bus in preference to car. The question relates to that particular journey and does not ask whether a car would usually be available.

11. If the rider did have a car available, the reasons why they chose not to use it, e.g., parking costs at destination, quicker by transit, etc.

12. Address or phone number of riders willing to take part in an interview survey about their use of bus services.

2. METHOD

The method consists of distributing a card and pen to riders as they get on the bus. This is then completed by riders while they are on the bus.

- o The cards are collected from riders as they get off the bus.
- o Each card has a serial number and is distributed in serial number order.
- o As the bus departs from a stop the serial number of the next card to be issued is recorded on a sheet containing a list of all stops on the route.
- o As the cards are handed in, they are collected into bundles corresponding to the stop at which the riders got off the bus.
- o Each bundle is then clearly marked with this stop. By these means, even if the riders do not complete the questionnaire on the card, as long as the card is handed in, we can identify where the rider got on and off the bus.
  - Hopefully, the riders encouraged by being issued with a pen or pencil, will provide at least some additional information.

It is important that the survey staff are familiar with the route being surveyed so that are always aware of where they are on the route in terms of the street intersections.

- o It is therefore recommended that the staff familiarize themselves with the route and its major landmarks in advance of carrying out the survey.

3. INSTRUCTIONS FOR TEAMS

(1) Teams will be comprised of two members, one with prime responsibility to distribute and one responsible for collecting the cards.

(2) Teams will board the bus at the beginning of the route before any riders get on the bus, and will ride on the bus from end to end of the route.

(3) Member 1. The "distributor", is issued with cards in serial number order and a recording sheet which shows the stops along the route in the order corresponding to the direction the bus is traveling in.

- As the riders board the vehicle and after they have paid their fare, they are handed a card and asked to complete the questionnaire.

(4) During the off-peak period, it should be possible to distribute a card to all riders (except children).

- During busy times such as during the peak, it may only be possible to distribute a card to every other rider or in extreme circumstances to one rider in three.

- For whatever rate is achieved, it is important to obtain a random sample of riders and to avoid distributing cards only to those riders who appear helpful.

(5) After the last rider has got on the bus and the doors have been closed, the serial number of the next card to be issued should be recorded against the name of the stop the bus has just left.

(6) At the end of the route, the serial number of the top card is recorded on the record sheet.

(7) The departure and arrival times of the bus should be recorded on the record sheet.

(8) Since many riders also get off the bus by the front door, the "distributor" will also endeavor to collect those cards which remain uncollected from these riders before they get off the bus.

- These cards will be handed to the "collector" at the earliest convenience to ensure they are included in the correct bundle.

(9) Member 2 - the "collector" is positioned next to the rear door of the bus and is responsible for collecting cards from riders as they get off the bus.

(10) As riders get off the bus, the "collector" should gather the cards into bundles.

- Once the bus has departed from each stop and the doors have been closed, the bundle of cards should be fastened together with an elastic band provided and marked with the name of the stop the bus has just left.

(11) At those stops where riders are also leaving by the front door, the "collector" may have to try and cover both doors, but should concentrate on the rear door relying on the "distributor" to cover the front door.

(12) At the end of the route, the bundles should be collected together in an envelope which should be marked with the time of the survey.

(13) <u>Both Team Members</u> will be issued with pencils or pens which should be offered to those riders who have nothing to write with.

- This can be done between stops if necessary.

(14) Riders should as far as possible be discouraged from returning their cards until they are going to get off the bus.

- Otherwise, there is no way of identifying where they do leave the bus.

(15) Any cards dropped on the floor of the bus should as far as possible be picked up to discourage other riders from dropping their cards.

(16) Postscript - Rather than attempting to cover every bus stop on the route, the survey will identify only those stops at the major street intersections, i.e., every half mile as shown on the attached map.

- The distributor will therefore record the serial number after the bus has departed from these stops only.

- The collector will collect cards into bundles corresponding to riders who get off at all stops within the half mile sections including the stop which marks the end of the section.

- Each bundle will be marked with the name of the stop which terminates the half mile section as listed on the record sheet.

(17) As teams board the bus, they should ask the driver to key into the farebox the code 999.

- When the teams get off the bus for a break or at the end of the survey, they should ask the driver to cancel the 999 code.

APPENDIX A(ii)

PLACE OF WORK SURVEY

1. PILOT SURVEY PLANNING AND IMPLEMENTATION

Self completion trade-off questionnaire surveys have been successfully conducted in Britain for people traveling to work. It was, therefore decided to adopt this technique in Chicago.

- o Rather than distribute questionnaires directly to respondents, selected employers were asked to distribute the questionnaires at their places of work.
- o It was hoped that this would help to improve the response rate, partly because many people could complete the questionnaire while at work, and any problems could be clarified.
- o The questionnaires would then either be collected by the employer or could be returned by mail (postage paid).

Having decided the method of distribution, the next stage was to design the questionnaire and to run a pilot survey to ensure that it could be understood and would provide the information required.

2. QUESTIONNAIRE DESIGN (See Figure 3 and 4)

The first page aimed to establish the mode of transport to work and its attributes in terms of time and cost.

- o Travel modes were either public transport - CTA, Metra and Pace - or private transport, car (driver and passenger) and walk.

The questionnaire then asked if an alternative way of traveling to work was available and asked respondents to detail the attributes of this mode.

- o The attributes of both the mode used and estimated or perceived values for the rejected mode were required as a basis for validating how people responded to the trade-off exercise.

- o Validation aimed to compare what people say they will do under a range of conditions with what they actually do under similar conditions; revealed preference versus stated preference.

The following estimates of journey attributes were included in the trade-off exercise:

- o Travel time

- o Walk and wait time for transit

- o Parking time and cost for car

- o Transit fares

For car travelers, the questionnaire attempted to establish whether the car was shared with other passengers and if so whether other travel costs such as parking were shared.

Pages 2 and 3 covered the trade-off exercise which consisted of 8 pairwise comparisons between traveling by car or by public transport under a range of different conditions.

- o It was considered that since the time to complete the questionnaire was not so critical as that for an interview survey, the respondent would be able to cope with a larger number of attributes.

- o All attributes except fare were assigned two levels while fare was assigned five.

The most significant attributes in influencing modal choice, were selected; fares were the prime concern.

- o Rather than adopting absolute travel times, travel time difference was selected as being more meaningful and also provided more economical data.

- Fare per month rather than fare per journey was adopted to include monthly pass journeys.

- Access time to transit represented by a combination of walking and waiting time was included as the major factor which differentiated transit from car. Parking cost and petrol price were included to represent the primary attributes of car travel.

- For non-CBD journeys, parking costs were replaced by parking time since this was considered to be more significant given that parking is free in many places of employment outside the Central Area.

  - Slightly different questionnaires to cover CBD and non-CBD employers were therefore drawn up.

Page 4 contained the socio-economic questions common to the other surveys.

As an incentive completed questionnaires were included in a draw; CTA monthly passes were the prizes. Following the pilot surveys, it was considered that this prize could introduce a bias in favor of CTA riders. The prize was therefore changed to be $100.

3. PILOT SURVEYS IMPLEMENTATION

The questionnaire was tested in two slightly different forms.

- At Peoples Light and Gas, at 122 N. Michigan Avenue, 450 questionnaires were distributed on 24th June. 100 were returned.

- At Seaway Bank, 160 questionnaires were distributed of which 80 returned.

The questionnaire was then revised slightly to increase the range of differences in the attribute levels, to strengthen the effect on mode choice particularly for gas price.

- The revised version was then distributed at Commonwealth Edison, at 1 First National Plaza on the 21st July.

  - Approximately 900 were distributed of which 200 were returned.

- It was not possible to secure the active cooperation of the employer in distributing questionnaires at the electricity and gas companies therefore they were distributed in the lobby of the buildings as people arrived in the morning.

- On the other hand, Seaway Bank distributed and collected the questionnaires themselves.

- The response rate was around 22% for the gas and electric companies and 50% for the Seaway Bank. This demonstrates the benefit of employer participation.

4. MAIN SURVEY PLANNING AND IMPLEMENTATION

The main survey was conducted during the latter part of August and during the month of September.

- 25 companies outside the CBD were selected to participate in the survey, questionnaires were sent to them with an accompanying letter giving instructions (See Figure 5, Page 8.)

- Within the CBD, questionnaires were distributed by survey staff outside selected office buildings to people arriving for work in the morning.

  - In the CBD, the returned questionnaires were predominantly from people traveling to work by public transport; car users were seriously under represented.

  - It was therefore decided to distribute questionnaires outside a range of parking lots to people arriving by car.

  - People were given the questionnaires between 8 a.m. and 9 a.m. on leaving the parking lot.

A total of 4000 questionnaires were distributed to employees outside the CBD of which 360 were returned, giving a response rate of 9%.

- o Within the CBD 4500 were distributed, of which 660 were returned giving a response rate of 15%. This was low compared to London where average response was of the order of 25-30%.

  - Figure 6 at the end of this Appendix, shows the locations of employers where the questionnaires were distributed.

The 200 questionnaires returned during the second pilot survey were included in the analysis of main survey results.

FIGURE 3

PLACE OF WORK QUESTIONNAIRE (Pages 1 & 4)

Thank you for your help. We would like to know a few things about you. This will help us to ensure that our survey represents all groups of travelers.

7. Are you: 1. ☐ MALE 2. ☐ FEMALE

8. Is your age:
1. ☐ 12-17
2. ☐ 18-24
3. ☐ 25-34
4. ☐ 35-44
5. ☐ 45-64
6. ☐ 65 or over

9. Are you:
1. ☐ Hispanic
2. ☐ Asian
3. ☐ Black
4. ☐ White
5. ☐ American Indian
6. ☐ Other

10. How many people live in your household?________

11. How many vehicles (car, van, or other) are available to you and members of your household?________

12. What was your combined household income last year? (1986)
1. ☐ Under $10,000
2. ☐ $10,000-$20,000
3. ☐ $20,000-$30,000
4. ☐ $30,000-$40,000
5. ☐ $40,000-$50,000
6. ☐ over $50,000

13. We will soon be undertaking a survey of how travelers would feel about alternative types of pass which we are studying. If you would be willing for us to mail you a survey questionnaire please indicate:
☐ Yes ☐ No

Now please fold the card in half and mail to CTA (no stamp required).

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 11103, CHICAGO, ILLINOIS

POSTAGE WILL BE PAID BY —
CHICAGO TRANSIT AUTHORITY
Mr. Evan Fowler
Special Project Liaison
Merchandise Mart, Box 3555
Chicago, Illinois 60654

staple or tape here

043 882

cta

YOUR FUTURE CTA SERVICE

We are carrying out a survey of your choice of transportation for your journey to work. We would be grateful if you would help us help you by completing the following questionnaire. Your replies will be treated with the strictest confidence.

To make the survey more interesting, we will be holding a drawing with a $100 PRIZE for the winner! If you wish to take part in this drawing, please write your name and address/phone number.

Name________ Phone No.________

Address________ Zip________

1. How do you usually travel to work from home?
☐ Drive a car
☐ Travel as a passenger in a car
☐ Travel by CTA, i.e. bus, rail or both
☐ Travel by METRA and/or PACE
☐ Walk all the way
☐ Other, please state ________

2. How many miles do you travel to work?
☐ Less than 2 miles
☐ Between 2 and 8 miles
☐ More than 8 miles

3. How long does it take you to travel to work?________mins.

4. If you usually travel to work by CTA, PACE or METRA:
a) How much do you pay in fares per month?________$ per month.
b) How long does it take you from leaving home to catching the bus or train (i.e. walking and waiting time)?________mins.

Could you alternatively:
c) Regularly drive a car to work? ☐ Yes ☐ No) If No to both
d) Regularly share-a-ride? ☐ Yes ☐ No) c & d, to to Q. 5

Please estimate:
e) How long it would take to drive to work (excl. parking)________mins.
f) How long it would take to find a space and park________mins.
g) How much per month it would cost to park your car________$ per month?

5. If you usually travel to work by CAR:
a) How much do you have to pay to park per month?________per month
b) How long does it take you to find a space and park?________mins.
c) If you share-a-ride, how many people including yourself travel in the car?________
Do you share travel costs? ☐ Yes ☐ No

Could you alternatively:
d) Travel to work by CTA? ☐ Yes ☐ No) If No to both
e) Travel to work by METRA/PACE? ☐ Yes ☐ No) d & e go to Q. 6

Please estimate:
f) The time from leaving home to catching a train/bus________mins.
g) The traveling time by transit to your place of work________mins.
h) The cost per month of transit fares________$ per month

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FIGURE 4 (Continued)

PLACE OF WORK QUESTIONNAIRE

(Pages 2 & 3)

6. How would you choose to travel to work in the following eight situations?

For example, in the first situation, you can either travel to work by car and pay $1.80 per gallon for gas and $200 per month for parking. OR you can spend 10 mins. walking and waiting for public transit (i.e. bus, rail or both) costing $40 per month and taking 10 mins. longer riding time. How would you choose to travel?

For the situations given below, please indicate, by checking the appropriate box, your strength of preference for car or transit based on your daily journey to work.

TRANSIT FACTORS: WALK/WAIT TIME	TRANSIT FACTORS: FARE PER MONTH	TRAVEL TIME DIFFERENCE	CAR FACTORS: GAS PRICE PER GALLON	CAR FACTORS: PARKING COST PER MONTH	Strongly Prefer Transit	Weakly Prefer Transit	Indifferent	Weakly Prefer Car	Strongly Prefer Car
10 Mins.	$40	10 Mins. Longer By Transit	$1.80	$200					
5 Mins.	$70	10 Mins. Longer By Transit	$1.80	$100					
5 Mins.	$55	5 Mins. Quicker By Transit	$1.80	$200					
5 Mins.	$60	10 Mins. Longer By Transit	$1.00	$200					
10 Mins.	$70	5 Mins. Quicker By Transit	$1.00	$200					
5 Mins.	$40	5 Mins. Quicker By Transit	$1.00	$100					
10 Mins.	$55	10 Mins. Longer By Transit	$1.00	$100					
10 Mins.	$60	5 Mins. Quicker By Transit	$1.80	$100					

FIGURE 5

LETTER TO EMPLOYERS

Chicago Transit Authority
Merchandise Mart Plaza, P.O. Box 3555
Chicago, Illinois 60654
(312) 664 7200

September 25, 1987

Dear

Following our telephone conversation, I ask if you will participate in our travel survey. This survey is designed to find out more about how people decide to travel to work, whether by car or public transportation. We would like you to distribute the enclosed questionnaires to a sample of your employees representing all departments and including people that travel to work by all ways of transportation--auto, bus, rail, walk. Your employees can then return them to us by mail, as each survey has a postage-paid business reply address printed on the back.

The survey forms are enclosed. You might want to point out that completed surveys are entered into a drawing for a cash prize.

Thank you for your help.

Sincerely,

E Sawyer

Ernest R. Sawyer
Deputy Executive Director
Planning, Marketing & Development

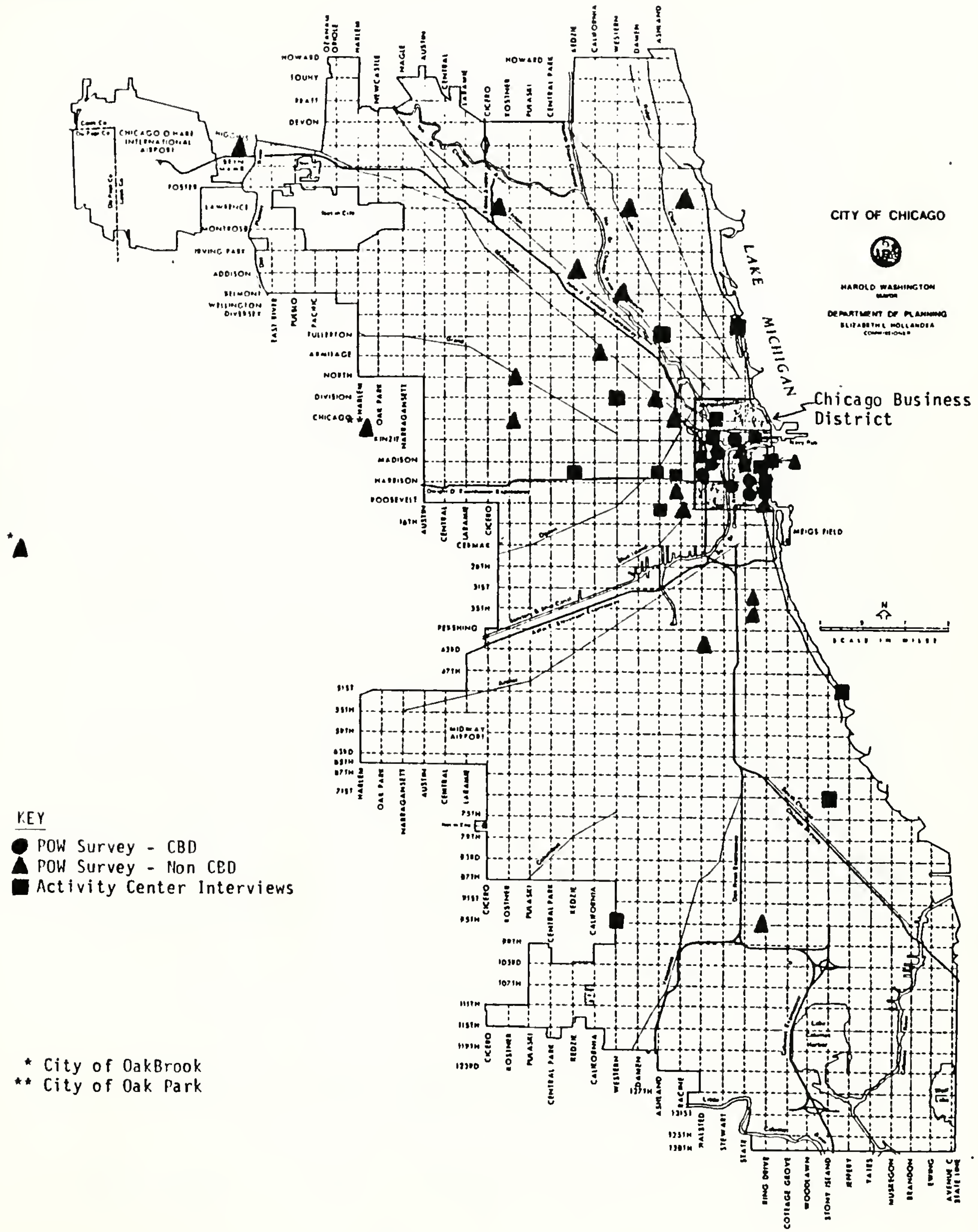
CPC/SJL:mlh

enclosures

d-17
1.13

Chicago Transit Authority

FIGURE 6
LOCATION OF SURVEYS



APPENDIX A(iii)

ACTIVITY CENTER SURVEY

1. INTRODUCTION

The Questionnaire Card Survey conducted on Route 94 had shown that transit riders had a range of travel alternatives. Therefore it would not have been meaningful to formulate a questionnaire based on a single binary choice of mode. It was decided to use an interview technique because:

- o Respondents could be categorized according to available alternatives during the first part of the interview.
  - An appropriate trade-off for each respondent could then be selected.
- o While it might have been feasible to design a questionnaire with filter questions leading to a range of trade-offs, the questionnaire would need to be complicated and extended.
- o The questionnaire could be easily and fully piloted. It was easier for the interviewer to determine the best way of phrasing each question and to ensure the respondent understood the trade-off exercise.
  - The questionnaire could be modified at low cost.
  - With a printed questionnaire there are high fixed costs associated with producing a small number of questionnaires.
- o The survey had to cover a broad range of respondent in terms of income, literacy, etc.
  - It would have been difficult to obtain a representative sample of all socio-economic groups with a self completion questionnaire.

2. INTERVIEW METHOD

A range of interview methods were considered. To obtain a meaningful database it was essential to:

- Include both users and non users within the survey
- Obtaining a representative sample of all households over the entire CTA service area

It was therefore decided that:

- All methods based on transit vehicles and stations or bus stops were ruled out
- Home interviewers were the obvious choice but ruled out on cost grounds
- A phone survey was considered seriously as providing a comprehensive yet economical way of obtaining a random sample of households over a wide geographical area.

However, once it was realized how complex the interview would need to be to accommodate the numerous travel alternatives it was considered impractical to conduct the survey by phone. It would have been necessary to establish the travel pattern of the respondent; then for each journey to establish the choice of mode; and then finally to carry out the trade-off exercise for a particular type of journey. The trade-off exercise is an especially difficult concept to explain without some form of visual aid. While this could have been mailed prior to the interview, the logistics of coordinating a mail drop and telephone call would have been difficult.

As an alternative to home interviews, group interviewing was considered, to reduce costs while retaining the advantage of interview-led assistance. Such interviews would need to have been organized in community centers or at some conveniently located CTA premises. However, it was likely to be difficult to attract a sufficient number of people to travel to such a center which may have been located in a different neighborhood than their own.

Conducting interviews on board buses and trains was considered because the respondent is captive at least for a limited period.

- o However, conditions on transit vehicles are not always conducive to interviewing given the limited privacy afforded the respondent and it is often difficult to retain the attention of the respondent who may be concerned about getting off the vehicle.

- o This method also suffers from being limited to transit users which would have necessitated an additional survey for non-users.

After considering the alternatives it was decided to adopt a method of interviewing based "activity centers".

- o Such centers attract large numbers of trips by all types of transport mode including car, public transport and walk.

It was considered that this was the most straightforward method of gaining access to both users and non-users of public transportation.

The Activity Center survey was designed to collect a random sample of journeys to a limited number of locations.

- o No attempt was made to randomly sample locations.

- o Locations were selected to ensure an adequate sample size in each of the desired categories. Further locations were added where a particular category sample was found to be inadequate.

  - This was therefore effectively a stratified sample. The aim was to collect a random sample of all journeys arriving at each location.

  - Interviewers were instructed to select people at random and avoid selecting only those respondents who appeared helpful.

As the survey proceeded, interviewers were instructed to select categories of respondent found to be under-represented when compared with Chicago's wider socio-economic and transport statistics.

3. DESIGN OF SURVEY AND QUESTIONNAIRE (Figures 7 to 10)

Once it had been decided to base interviews at Activity Centers, the questionnaire was formulated on the basis of necessary information to be collected, while taking account of the situation in which the interviews was to be conducted.

- The aim was to interview respondents on arrival at the Activity Center.

- All questions were to be phrased in the context of the journey just completed.

The journey was defined as starting from their last location of activity - in most cases home.

- This had the advantage that the journey was complete but still fresh in their minds. There was therefore no ambiguity about the journey being asked about. It was also easier to question the available transport alternatives for the journey just completed.

It was estimated that the maximum length of time a respondent would be prepared to be interviewed for was 10 minutes.

- Although the journeys being sampled were all non-work and there was not the same emphasis on time, it is difficult to conduct interviews without prior warning.

- The interview was therefore kept as short as possible to include only the very basic essential information.

The questionnaire is shown in Figures 7 to 10 at the end of this Appendix. This shows the final design after modifications implemented during the course of the survey work.

- Page 1 covered the revealed preference data including all attributes of the journey the respondent had just completed.

- The respondent's estimates of the attributes of a possible alternative mode of travel was also given in Page 1.

The summary of journey attributes is as follows:

a) Actual Arrival Mode of Transport

b) Location of Origin of Journey

c) Journey Distance

d) Traveling Time

e) Parking Time (for Car Users)

f) Fare

g) Whether Journey Necessitated a Transfer

h) Waiting Time for First Transit Vehicle

i) Alternative Mode of Transport (next best option) or Choice Not to Travel

j) Estimates of Attributes 6, 7, 8 for Car Users

k) Estimate of Attributes for Transit Users

On the basis of the replies given to questions on Page 1, respondents were classified into four groups:

i) Those who had not used CTA services for the last 5 years

ii) Those who had arrived by CTA services but could have by car, and vice versa

iii) Those who arrived by CTA services but could have walked, and vice versa

iv) Those who arrived by CTA services and said they would not have traveled if the service was not available.

Each of the groups (ii) to (iv) were then asked to carry out one of the three trade-off exercises on Page 2.

- Each exercise was designed to accommodate a trade-off against the respondent's choice of mode.

- CTA versus car (driver or rider)
- CTA versus walk
- CTA versus not travel

The last category does not constitute a modal choice but considered to be the only realistic choice available to some people.

- o However excluding this option, it was felt that people would be constrained to estimate trade-offs which they did not make in reality.

Each respondent was asked to state how likely they would have been to choose between two alternatives under a range of different situations in which the attributes of each option varied.

- o Each exercise involved eight pairs of alternative situations.

The aim of the survey was to estimate peoples' response to journey to explain their choice of mode to a maximum extent. For some people, fare may not be the most important factor in deciding how to travel; a model seeking to explain mode choice would be inadequate if fares were the only journey attribute included.

In order to limit the number of trade-off pairs to eight, the maximum number of attributes which could be accommodated by the survey design was three.

- o It was not possible to choose three attributes which were common to all three categories, because the significant attributes depended upon the particular trade-off involved.

- o For the choice between car and transit, parking time, transit fare and the availability of a direct transit service were selected as the most important.

Difference in travel time between transit and car was considered but excluded in preference to parking time; for many journeys, car users would be more aware and better able to estimate parking time. Parking cost was ruled out because it is

only significant in the central area. Car passengers were assumed to experience the same parking time as the driver, not the case with cost. This would not be accurate for those people dropped off by the car driver.

- For the choice between walk and transit, walking time, waiting time for transit and transit fare were selected.

- For short journeys for which walk was an attractive choice, it was felt that waiting time for transit was probably more important than the need to make a transfer. Transfers are not usually so necessary for very short journeys, whereas waiting time is likely to be a major influence on the decision whether to walk or not.

- For riders who do not have a choice other than not to make the journey, transit effectively competing with alternatives for both fare and time.

The components of traveling time which are usually perceived as most arduous, are the walk and wait time for transit both at the start of the journey and during transfers.

- These were therefore combined into two attributes; a combined walking and waiting time and the need to make a transfer or not. Fare was also included as the third attribute.

In all trade-offs, all attributes except fare took two levels. Fare, which was the prime concern, was allowed five levels to allow greater precision in the estimation of this parameter during analysis.

There are various alternatives for the order in which the eight pairs of trade-off are arranged.

- For this study, they were arranged such that the first two pairs provided the greatest contrast in the desirability of each alternative; thus the respondents understood the meaning of the exercise more easily.

Each of the eight pairs of choices were displayed on a card with pictures illustrating the various attributes (See Figure 10).

- The pictures were designed to aid understanding and to help make the interview more interesting.

- The interviewer was supplied with a deck of eight cards for each of the three alternative categories of trade-off.

- Having established the appropriate category for each respondent from the replies on Page 1, the interviewer would take the appropriate card deck and hand the cards or show the cards to the respondent in sequence.

Those respondents who claimed not to have used CTA for over 5 years were only asked the questions contained on Page 3 of the questionnaire.

- Page 3 of the questionnaire included socio-economic questions which were used to check that the sample of respondents was representative of the population being surveyed.

    - As far as possible, these questions were phrased exactly as those included in the other surveys.

4. PILOT SURVEYS

A trial of about 60 interviews was conducted on the 25 and 26 of June at Lincoln Park Zoo and at Water Tower Place. This aimed to test the feasibility of the trade-off interview in terms of respondent comprehension and acceptability.

- The interviews were found to last about 10-12 minutes to cover all 8 trade-off pairs.

    - Little difficulty was encountered in getting people to complete the interview.

    - However, some of those interviewed had never used CTA and had difficulty in completing the trade-off section with any meaning.

    - Later surveys, therefore, had a filter question at the beginning to establish the frequency of CTA use.

The results of the trade-off section were not fully analyzed. Instead, the average scores for each of the eight trade-offs were computed to check that the variation in score changed in a manner consistent with the variation in attribute level.

- For example, as transit waiting time increased the score indicating the strength of preference for transit decreased.

- While it was found that all attribute scores moved as expected, some variations were very small.

- As a result of the pilot survey, the attribute levels were therefore modified slightly to increase the difference. The order of the 8 pairs was also modified to introduce greater contrast between pairs near the beginning rather than towards the end.

For the remainder of the survey, Pages 2 and 3 were not modified. Page 1 continued to be altered in some minor details. However, these changes were significantly small so as to allow the survey data from all interviews following the pilot survey to be included in the main data analysis.

5. MAIN SURVEYS

Approximately 900 interviews were conducted at 25 different Activity Centers.

- The Activity Centers were selected to achieve a maximum range of journey purpose and good geographical dispersion throughout the CTA service area.

- No attempt was made to select locations at random.

- The number of interviews was controlled to a certain extent to achieve the approximate split between CBD and non-CBD journeys indicated by the CATS data.

The Activity Centers included in the survey were of the following nature:

- Shopping Centers

- o Leisure and Recreational Centers
- o Hospitals and Health Centers
- o Libraries
- o Cultural Centers

The survey commenced in mid-July and continued throughout the summer until mid-September.

- o The duration of the survey work permitted careful monitoring of the progress of field work and allowed the direction or emphasis to be effectively controlled.
- o At times, the weather was very hot (particularly during the early part of August). Since all interviews were conducted outside, the length of shifts for fieldworkers was limited.

For the main survey, the questionnaire was translated into Spanish to ensure an adequate sample of non-English speaking Hispanics.

- o One bilingual team of interviewers was assigned to those centers where there was a large Hispanic population.

The field force consisted of 8 interviewers working in pairs as 4 teams.

- o Interviews were generally conducted between 10.00 a.m. and 4.00 p.m. to avoid people traveling to or from work.

Approximately 900 interviews were conducted of which about 100 were respondents who were non-users of CTA services and so did not complete the trade-off exercise.

As a means of improving the response rate, a prize draw of $100 was offered.

FIGURE 7

ACTIVITY CENTER SURVEY INTERVIEW (Page 1)

cta Hello, MK.VII

We are conducting a survey for CTA into the use of their services.
Could you tell me if you live in the Chicago area:? YES/NO
(IF NO,GO ON TO NEXT RESPONDENT)

(IF YES) Could you help us by answering a few questions about how you traveled here today? Your answers will help plan the future public transit of our city. To make the survey more interesting, we will be holding a DRAWING WITH A $100 PRIZE for the winner!!!

1.When did you last use CTA services? ....

(IF NEVER) Please state main reasons which have dissuaded you from using CTA..............................(GOTO Q.6)

2.(IF YES) How did you get to this (shopping centre) today?

Drove a car/got ride in car A (CIRCLE LETTER &
Came by bus and/or train B UNDERLINE MODE)
Walked C
Other please state.........................

3.What location did you come from? (PROBE FOR STREET INTERSECTION)

......................Street and.......................Street

3a.How far is that location from here?.........miles(appr)

3b.How long did it take you to get here?........mins(appr)

3c(FOR CAR USERS)
How long did you take to find a parking space and park?.......mins.
(NOW GOTO Q.4)

(FOR WALKERS)How long did it take you to walk here?..........mins.
(NOW GOTO Q.4)

(FOR TRANSIT USERS)
Did you have to transfer? YES NO
What fare did you pay?............
How long did you have to wait for your 1st bus/train?.........mins.
(NOW GOTO Q.5)

4.If you had come by bus/train:
Would you have had to make a transfer? YES NO
What fare would you have to pay?............
How long would you have to wait for your 1st bus/train?.......mins.
(ASSIGN RESPONDENT TO GROUP AB OR BC THEN GOTO NEXT PAGE)

5.If you had not come by bus/train,how would you have come here or would you not have made the trip?

Driven a car/got ride in car A (CIRCLE LETTER &
Walked C UNDERLINE MODE)
Not have made the trip D
Other please state................................

5a.(FOR THOSE GIVING A)How long do you think it would take to find a space and park your car?................mins.

(FOR THOSE GIVING C)How long would it take to walk?.......mins

(ASSIGN RESPONDENT TO GROUP AB,BC OR BD AND GOTO NEXT PAGE)

FIGURE 8

ACTIVITY CENTER SURVEY INTERVIEW (Page 2)

(FOR GROUP AB TRANSIT VERSUS CAR)

Imagine that you are about to make a trip to a location similar to this. How would you choose to get here? Each of these cards gives you a choice of travelling here by transit or by car under a range of different conditions. (SHOW CARD TO RESPONDENT AND EXPLAIN AS FOLLOWS) If you choose car - the time it takes to park your car.If you choose transit - the fare and whether or not you have to make a transfer to get here. If you were given this choice, could you tell me whether you would be:

	1	2	3	4	5	6	7	8
Very likely to travel by transit								
Likely to travel by transit								
Indifferent between transit and car								
Likely to travel by car								
Very likely to travel by car								

Now could you please do the same for this choice (SHOW 2ND CARD TO RESPONDENT. REPEAT FOR ALL 8 CARDS.THEN GO TO Q.6)

(FOR GROUP BC TRANSIT VERSUS WALK)

Imagine that you are about to make a trip to a location similar to this. How would you choose to get here? Each of these cards gives you a choice of travelling here by transit or by walking under a range of different conditions. (SHOW RESPONDENT 1ST CARD AND EXPLAIN AS FOLLOWS) If you choose to walk - the time it takes to walk here.If you choose transit - the fare and how long you have to wait for transit. If you were given this choice, could you tell me whether you would be:

	1	2	3	4	5	6	7	8
Very likely to walk								
Likely to walk								
Indifferent between walk and transit								
Likely to travel by transit								
Very likely to travel by transit								

Now could you please do the same for this choice (SHOW 2ND CARD TO RESPONDENT. REPEAT FOR ALL 8 CARDS. THEN GO TO Q.6)

(FOR GROUP BD TRANSIT VERSUS NOT TRAVEL)

Imagine that you were about to make a trip to a place similar to this.Each of these cards (SHOW 1ST CARD AND EXPLAIN) shows a range of transit service in terms of the waiting time for transit, the fare and whether or not you have to make a transfer to get here.If you had no alternative but to travel by transit, could you tell me for this level of service whether you would be:

	1	2	3	4	5	6	7	8
Very likely to make the trip								
Likely to make the trip								
Indifferent to making the trip								
Unlikely to make the trip								
Very unlikely to make the trip								

Now could you do the same for this level of service (SHOW NEXT CARD AND REPEAT FOR ALL 8 CARDS.THEN GO TO Q.6)

FIGURE 9

ACTIVITY CENTER SURVEY INTERVIEW (Page 3)

(FOR ALL GROUPS)

6.How many people live in your household?............

7.How many vehicles(car, van or other) are available to you and members of your household?.................

8.To ensure that our survey represents people in all age and income groups could you indicate which age group you are in and which income group would apply to your household last year(1986)?

AGE GROUP

Under 18	25 - 34	45-64
18 - 24	35 - 44	65+

INCOME GROUP

Under $10000	$20000-$30000	$40000-$50000
$10000-$20000	$30000-$40000	Over $50000

9.(INDICATE SEX)   Male   Female

10.(INDICATE RACE)

Hispanic	Asian	Black
White	American Indian	Other

Thank you very much, that completes the interview. My supervisor may want to call you to verify that I have completed this interview. May I have your name and phone number so that she may do so? Also, if you want to participate in the $100 prize drawing we will need to be able to contact you.

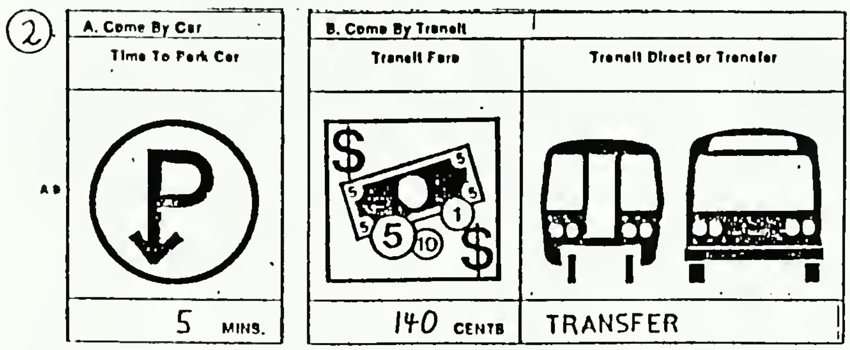
NAME...

PHONE NO: Day............Evening.....................

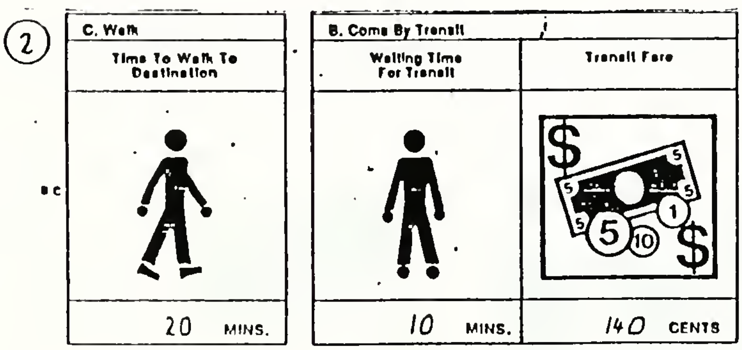
ADMINISTRATIVE DATA.
Interviewer name................................
Interview date and day of week..................
Time interview started..........................
Time interview ended............................

FIGURE 10

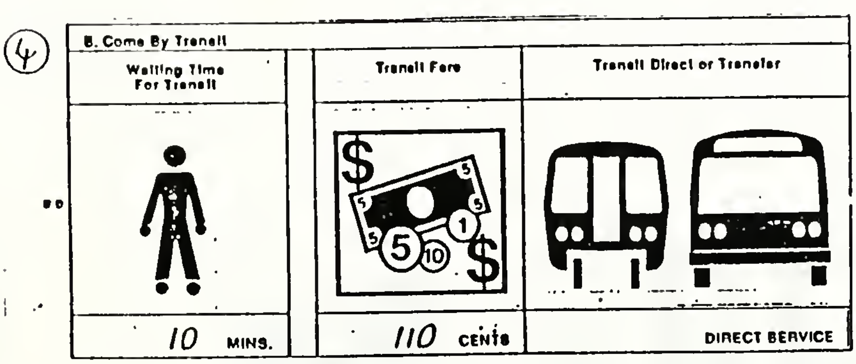
TRADE-OFF CARDS USED DURING ACTIVITY CENTER SURVEY INTERVIEW



TRANSIT VS.
CAR
TRADE-OFF

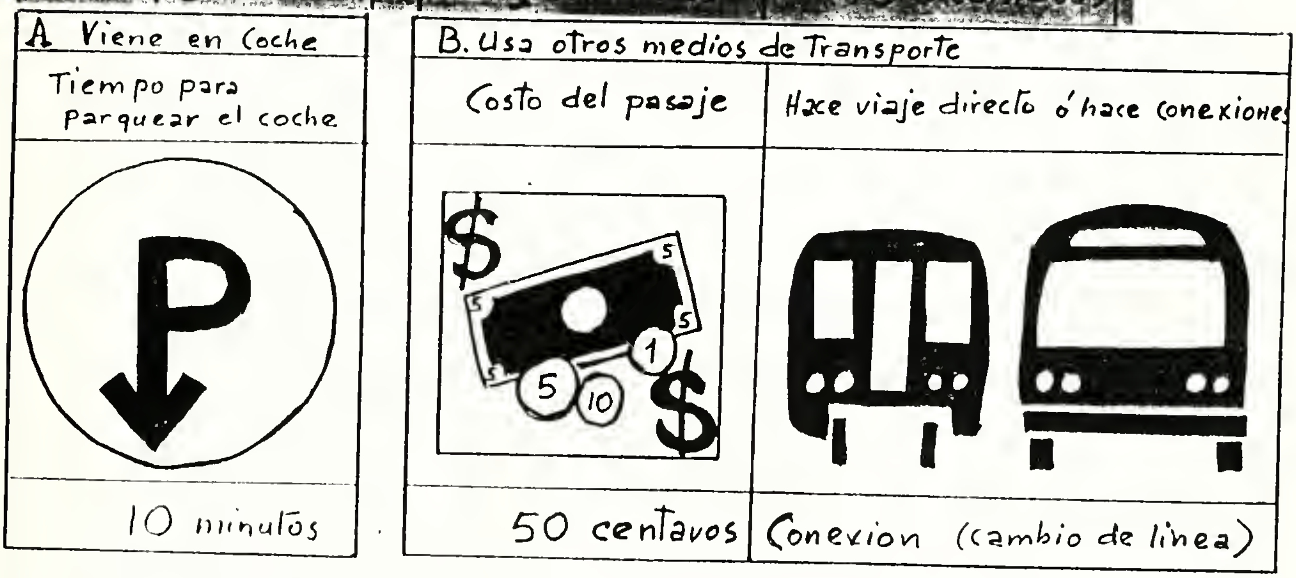


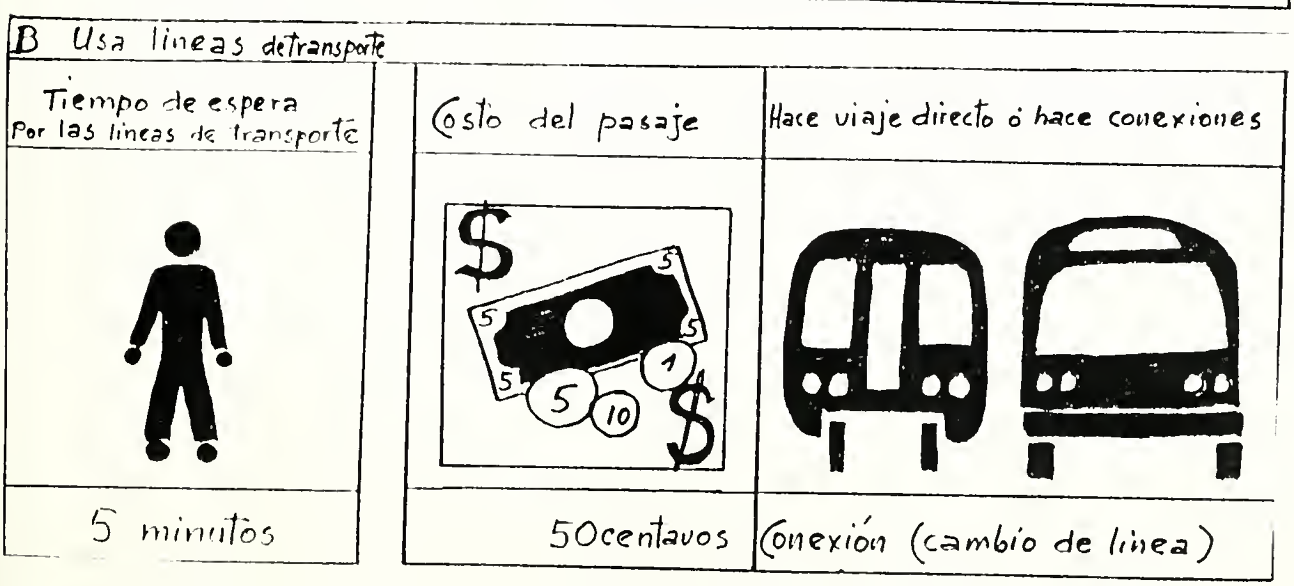
TRANSIT VS.
WALK
TRADE-OFF



TRANSIT VS.
NOT TRAVEL
TRADE-OFF


C. Caminando
Precio del pasaje
40 minutos
50 centavos


A Viene en Coche
Tiempo para
Parquear el coche
10 minutos
B. Usa otros medios de Transporte
Costo del pasaje
Hace viaje directo ó hace conexiones
50 centavos
Conexion (cambio de linea)


B Usa lineas de transporte
Tiempo de espera
Por las lineas de transporte
5 minutos
Costo del pasaje
Hace viaje directo ó hace conexiones
50centavos
Conexión (cambio de linea)

Buenos dias.

Estamos llevando a cabo una encuesta para la CTA (Autoridad de Transporte de Chicago) acerca del uso de sus servicios. Podria UD. decirme si vive en el area de Chicago? Podria Ud. ayudarnos contestando a unas cuantas preguntas acerca de como viajo Ud. aqui hoy? Sus respuestas nos ayudaran a planear el futuro medio de transporte publico de nuestra ciudad. ¶ Para hacer la encuesta mas interesante tendremos un Sorteo con $ 100.00 (cien dolares) de premio para el ganador.

1. Usa Ud. siempre los servicios de la CTA.?
   (Si la respuesta es NO,) Por favor de Ud. sus razones (diga por que no usa Ud. estos servicios.)
2. Como llego Ud. a este Shopping Centre?
3. De que lugar vino Ud.?
   a. Cuanto demoro en llegar aqui?
4. Si Ud. no hubiera venido en..............de que otra forma hubiera venido aqui, o no hubiera hecho Ud. el viaje?
5. Por que no vino Ud. en .... esta vez?
6. Cuantas personas viven con Ud.?
7. Cuantos vehiculos (automovil, van, u otros) estan disponibles para Ud. y los miembros de su familia?
8. Para estar seguros que esta encuesta representa a personas de todas las edades y de todos los niveles economicos,podria Ud. indicarnos:
   Segun la edad, a que grupo pertenece Ud.? y
   Que grupo le corresponde de acuerdo a las entradas o a las ganancias obtenidas el ano pasado (1986).

   INGRESO ANUAL:

menos de $ 10,000	$ 20,000 - $ 30,000	$ 40,000 - $ 50.000
$ 10,000 - $ 20,000	$ 30,000 - $ 40,000	sobre 50,000

9. Sexo
10. Raza

Muchas gracias por aceptar la entrevista. Me quisiera dar su nombre y su numero telefonico para que mi supervisor pueda verificar con Ud. que los datos estan correctos?

Ademas, si Ud. quiere participar en el Sorteo de $ 100.00 necesitamos comunicarnos con Ud.

(PARA GRUPOS AB TRANSIT VERSUS AUTOMOVIL)

Imagine que Ud. va a viajar a un lugar similar a este.Como haria para llegar aqui?
Cada una de estas tarjetas le da a Ud. a escoger entre viajar aqui por medios de transporte local o por automovil, bajo una serie de diferentes condiciones.
Si Ud. escoge automovil - el tiempo que toma en parquear su coche.
Si Ud. escoge lineas de transporte local - el precio del pasaje y si tiene que hacer o no una conexion para llegar aqui.
Si a Ud. se le diera a escoger, me podria contestar a lo siguiente?

- estaria muy seguro de usar las lineas de transporte local
- seria probable que use las lineas de transporte local
- le seria indiferente usar las lineas de transporte local o el coche
- seria probable que viaje en coche (automovil)
- estaria muy seguro de viajar en coche

1	2	3	4	5	6	7	8

(MOSTRANDO LA 2da. TARJETA AL ENTREVISTADO)Ahora podria hacer la misma seleccion por favor?

(PARA GRUPOS BC TRANSIT VERSUS WALK)
Imagine que Ud. va a viajar a un lugar similar a este. Como haria para llegar aqui?
Cada una de estas tarjetas le dan a Ud. a escoger entre viajar aqui por los medios de transporte local o caminando, bajo una serie de diferentes condiciones.
Si Ud. decide caminar - que tiempo le toma para llegar aqui?
Si Ud. escoge las lineas de transporte local - el valor del pasaje y cuanto tiene que esperar por el bus o el tren.
Si se le diera a escoger, me podria decir si Ud.

- estaria muy seguro de caminar
- seria probable que camine
- le seria indiferente entre caminar o usar las lineas de transporte local
- seria probable que use las lineas de transporte local
- estaria muy seguro de usar las lineas de transporte local

1	2	3	4	5	6	7	8

(MOSTRANDO LA TARJETA AL ENTREVISTADO) Ahora podria hacer la misma seleccion por favor

---

(PARA GRUPOS BD TRANSIT VERSUS NO VIAJAR)
Imagine que Ud. va a viajar a un lugar similar a este.
Cada una de estas tarjetas (MUESTRE LA 1ra. TARJETA Y EXPLIQUE) muestran una serie de servicios de transito con datos referentes al tiempo de espera por la linea, al precio del pasaje, y si Ud. tiene o no,que hacer una conexion para llegar aqui.
Si Ud. no tuviera otra alternativa sino que usar las lineas de transporte, me podria Ud. decir teniendo en cuenta todas estas condiciones,si:

- estaria muy seguro de hacer el viaje
- seria probable que haga el viaje
- le seria indiferente hacer el viaje o no
- no seria probable que haga el viaje
- estaria muy seguro de no hacer el viaje

1	2	3	4	5	6	7	8

APPENDIX B

Stated Preference Design, Analysis and Parameter Evaluation Tests

APPENDIX B

STATED PREFERENCE DESIGN, ANALYSIS AND PARAMETER EVALUATION TESTS

1. INTRODUCTION

This Appendix provides a more formal presentation of the Stated Preference experiment and analysis techniques outlined in Section III. Reference is made to the main report to avoid repetition. The structure of the Appendix is as follows:

- Questionnaire Design
- Disaggregate Analysis Methods:
  - Linear Strength of Preference
  - Log Odds Analysis
  - Inferred Mode Use
- Extension to Multinomial Choice
- Market Segmentation
- Parameter Tests of Reasonableness:
  - Elasticities of Demand
  - Values of Time
  - Validation
- Analysis of Second Best Alternative
- Analysis of Never Travel by CTA

2. QUESTIONNAIRE DESIGN

The Stated Preference (SP) experiment was set up as a series of pairwise comparisons of attribute sets.

- o The pairs of attributes or factors described two travel modes eg car and transit.
- o Respondents were asked to state their strength of preference for one set (eg transit) over the other set (eg car) for each of the pairwise comparisons.

The sets featured five factors in the journey to work survey distributed principally at place of work (PW). The non-journey to work survey, administered at Activity Centers (AC) featured three factors.

- o Transit fare was present in all comparisons: the other factors depended on the type of survey (PW or AC) and, in the AC, the modal comparison (ie whether transit was compared to car, walk or not travel).

The preference for one travel mode over the other was designed to be explained by the levels taken by the factors.

- o For transit fare, four levels were specified; the other factors had two levels.
  - Figure 3.2 and 3.3 in Section III presented the factors and levels in both surveys.

Eight pairwise comparisons were presented in both surveys.

- o Having more than one pairwise comparison enabled the isolation, hence estimation, of the importance attached to individual factors.
- o However, full factorial experimental designs were not adopted.
  - These designs would have ensured that the main effects were not confounded by two way and three way interactions.
  - That is, the pure effect of transit fare could be estimated and separated from the combined effect of changes in transit fare and transit journey time.
- o Full factorial designs given the number of factors and levels taken would have required 64 pairwise comparisons in the PW survey and 16 pairwise comparisons in the AC survey.

Although, split plot designs could have been developed (eg 8 questionnaires of 8 pairwise comparisons for the PW survey) it was considered that any two way and higher level interactions would be negligible: Their size would not warrant the extra administrative/analysis costs.

- o A fractional factorial design was instead adopted.
- o Its construction ensured that there was no correlation between factors.
  - Higher transit fares, for example, were not associated with longer (or shorter) transit wait times.

3. DISAGGREGATE ANALYSIS METHODS

This section presents a more detailed description of the disaggregate techniques and the four analysis techniques which have been used to produce parameter estimates on the data bases briefly described in Section III of this report.

- o The Analysis of Means: an aggregate technique does not require any further description.

As Section III.2 stated, the techniques differ in three respects:

(i) The conversion of the strength of preference response categories;

(ii) The functional form of the relationship between the response measure and the factor levels; and,

(iii) The estimation technique.

- o This section focuses on (ii) and (iii). Section III of this report provided detailed coverage of (i).

Some comments are made below on the strength and weaknesses of each technique.

(1) Linear Strength of Preference

The general form of the estimation equation is:

$$SPT = Bo + \sum BiXi + e \qquad (B1)$$

where:

SPT = Strength of preference for Transit
Xi = level taken by factor i describing transit or alternative (eg car)

e = error term
Bo, Bi = parameters to be estimated

The constant (Bo) is a measure of the unexplained preference towards or away from transit.

Adopting the linear scale shown in Section III, a parameter estimate of value 3 indicates indifference.

- o Divergence away from 3 indicates unexplained preference.

- o For statistical analysis, it is easier if a value zero implies indifference.

  - This can be achieved straightforwardly by subtracting 3 from the strength of preference ie (SPT-3).

  - This transformation was performed.

- o Equation B1 was estimated by Ordinary Least Squares (OLS) regression.

The Linear Strength of Preference is the easiest to estimate and interpret.

- o It has two major drawbacks however:

  (i) 'Unbounded' predictions - may predict strengths of preference outside the range (-2 to +2)

  (ii) Extra forecasting step - forecasts of mode share and elasticity measures require an extra step

- o The extra forecasting step translates the strength of preference into a probability of mode use.

  - Details are provided in Section B6.(1)

- o Constraints may be placed on predictions to bound them within the -2 to +2 range. Or, alternatively, predictions outside this range may be allowed; their effects catered by the probability of use translation which bounds predictions to the 0, 1 interval.

(2) Log Odds Analysis

This measure converts the strength of preference into a probability of use measure.

- o The measure can be estimated by OLS using a logit model form.

- o The conversion retains the ordinal difference between strong and weak preference; it is bounded within a 0-1 interval and enables all observations to be used without observation weighting.

- o The conversion does assume that strength of preference can be directly related to probability of use - it is conceivable that an individual may prefer a mode but for certain reasons not actually use it.

  - The extent to which stated and revealed preferences diverge may be assessed through validation (see Section B6).

The derivation of the logit model is set out below, Pt is the probability of using transit. U is the utility and t and c denote transit and car respectively.

$$Pt := \frac{e^{Ut}}{e^{Ut} + e^{Uc}} \qquad \text{(B2)}$$

Dividing through by" e^{Ut} we obtain:

$$Pt := \frac{1}{1 + \frac{e^{Uc}}{e^{Ut}}} := \frac{1}{1 + e^{-(Ut-Uc)}} \qquad \text{(B3)}$$

The equation can be linerized to facilitate estimation:

$$Pt \left[1 + e^{-(Ut-Uc)} \right] := 1$$

Where:

Pt	= The probability of using transit	(B4)
U	= Utility	
Pt	= Probability of using transit	
t,c	= Denote transit and car respectively	

Dividing by Pt and subtracting 1 gives:

$$e^{-(Ut-Uc)} := \frac{1}{Pt} - 1 = \left[1 - \frac{Pt}{Pt}\right] \qquad [B5]$$

Knowing that $e^{-z} := \frac{1}{e^{z}}$ we may write:

$$e^{Ut-Uc} := \frac{Pt}{1 - Pt} \qquad [B6]$$

Taking logarithms of both sides gives:

$$\ln\left[\frac{Pt}{1 - Pt}\right] := Ut - Uc \qquad [B7]$$

The utility expression for the two modes (transit and Car) may be represented as a linear function of the factors plus associated parameters. With error term the estimation equation is:

$$\ln\left[\frac{Pt}{1 - Pt}\right] := B_o \sum B_i X_i + e \qquad [B8]$$

Which can be estimated by OLS.

(3) Inferred Mode Use

The strength of preference is converted into a dichotomous variable eg (1,0).

- o A value of one implies use of transit (strong or weak preference for transit) a zero value implies use of car.
- o Some information is therefore 'lost' during conversion since weakly and strong preferences are grouped together and indifferent preferences have to be treated differently.
- o Rather than discard them or assign them to their current mode which would be effectively arbitrary a weighting technique may be employed.

For each indifferent observation a value of 1 and a value of 0 is assigned ie the observation appears twice in the data set once as a transit user, once as a car user.

- o Both observations are assigned a weight of one half with all other observations assigned a unitary weight.

The model form is the same as the Log Odds model except that the dependent variable is dichotomous (0,1) which prohibits OLS regression.

- o Maximum likelihood may however be used to estimate the model parameters.

- o This estimation technique attempts to find those parameter estimates which are most likely to have led to the observed choices stated to the SP experiment.

Although the input into the inferred Mode Use (IMU) estimation model is based on 'all or nothing' assignment (eg transit or car in the PW survey) the output is a probabilistic measure of mode usage with probabilities lying between zero and one.

- o The output is therefore identical in form to the output from the Log Odds Analysis (LOA).

- o The estimated parameters will not be identical however because of the different conversion scales adopted to translate strength of preference into mode usage.

The tendency will be for the IMU parameters to be greater that the LO parameters:- a result of the greater range in dependent variable (0,1) required to be explained by the IMU parameter than by the LO parameter (0.1, 0.9).

4. EXTENSION TO MULTINOMIAL CHOICE

The AC survey presented respondents with one of three SP experimental designs:

- Transit car,
- Transit walk, and
- Transit-not travel.

The experimental design administered depended on the respondents current mode which if transit depended on their second best alternative (SBA).

- o Each SP experiment may be analyzed separately using binary models or together using multinomial (MNL) models.

The MNL model is shown below:

$$P(transit) := \frac{e^{U(transit)}}{e^{U(car)} + e^{U(transit)} + e^{U(walk)} + e^{U(not\ travel)}} \qquad [B9]$$

The MNL assumes that each alternative specific choice probability is unaffected by the utility level of any other mode:-

- o This property is referred to as Independence from Irrelevant Alternatives (IIA).
- o The presence of transit in all three trade offs and the IIA property allows the extension of the binary model to the multinomial case as shown mathematically below:

$$\frac{Pt}{Pc} := \frac{e^{Ut}}{\Sigma e^{Uj}} - \frac{e^{Uc}}{\Sigma e^{Uj}} := \frac{e^{Ut}}{E^{Uc}} := e^{Ut-Uc} \qquad [B10]$$

The IIA property implies that a decrease in transit fare would draw patronage from other travel alternatives in proportion to their base shares.

- The shares of any two non-transit alternatives is left unaffected.

The additional analysis steps to those required for the binary model are set out below:

- Appendage of the three SP experiment data sets to form a 'grand' data set;
- Creation of a common dependent variable (i.e., strength of preference of using transit relative to non-transit modes);
- Insertion of mean values for attributes not present in all SP experiments.
  - For example, the mean difference in level for the wait time attribute (7.5 mins) is inserted into all the car SP experiment observations; and
- Computation of dummy variables to classify the three SP experiments data sets as shown below.

	SP Experiment		
	CAR	WALK	NOT TRAVEL
DV1	0	0	1
DV2	0	1	0

Together, the model constant and the estimated parameters associated with DV1 and DV2 provide the unexplained preference for (or against) each travel alternative.

- The unexplained preference for car is given by the estimated constant term.
- The unexplained preference for walk is given by the estimated constant plus the parameters DV1.

- o Similarly, the unexplained preference for not-travel is given by the estimated constant plus the parameter DV2.

Binary model estimation produces SP experiment specific parameter estimates.

For fare, three parameter estimates are produced - one per SP experiment.

- o MNL estimation produces one parameter estimate per-factor:- a weighted average of the binary model estimates.
- o The weights are equal to the relative number of observations in each tradeoff data set.
- o Standard errors and 't' values reflect the increase in observations and any response differences between the SP experiments.

Binary and MNL models may be compared in terms of:

- o Theoretical properties
- o Forecasting properties

(i) Theoretical Properties

The MNL provides a single fare parameter estimate. In contrast, binary models provide estimates for each SP experiment (or for each SP experiment/mode combination).

- o There is however little theoretical justification for SP experiment/mode specific estimates and differences simply reflect 'self selection'.
- o Slow but cheap modes are patronized by individuals with relatively low values of time compared to users of fast but expensive modes.
- o Although, the binary models reflect self selection they do not account for it by reference to the socio economic characteristics of users.

(ii) Forecasting Properties

In terms of forecasting, binary models will provide more accurate forecasts if inter mode differences are greater than intra mode differences.

- o Parameters need to be compared not only in terms of their size but significance.
- o Although the binary models may produce different estimates the statistical confidence associated with any difference may be weak.
- o Consequently, the standard error of the forecast based on the individually estimated pararmeters may be greater than the pooled observation model.

Treatment of Trip Suppression/Generation

There are two problems:

- o Only travel users were surveyed.
  - Those who had suppressed their trip because of the characteristics of the available travel modes were not surveyed.
  - These individuals may have a different sensitivity to fare. If this is the case the mean fare estimate will be biased when used to forecast trip generation.
- o MNL and binary models traditionally assume a fixed travel market (i.e., exclude generation or suppression).
  - This study has found that many transit users do not have an alternative mode available to them: it is too far to walk and they do not have a car available.

- Their decision when faced with a transit fare rise is binary 'to travel or not to travel'. It does not include the option of changing travel mode.

The two problems can be tackled by:

- o Assuming generation is a mirror image of suppression;
- o Using the transit 'not travel' parameter provides a fare elasticity of demand which can then be applied to the proportion of transit users whose SBA is 'not travel'; and
- o Using a 'direct demand' approach with a constant elasticity

In the context of this study, the logit based elasticities of demand measure the change in probabilities of using transit (and, by subtraction, not traveling) associated with a change in transit fare.

Base mode shares are needed for forecasting.

- o This information will not be available for the transit - not travel market.
- o Initially, it is proposed to take the elasticity of demand estimated for the 'not travel' SP experiment and input it into a direct demand equation as shown below:

$$Q1 = Qo + E(F/FO)\ Qo \qquad \text{(B11)}$$

where Q = transit trips where SBA is not travel
F = fare
E = elasticity of demand
0,1 = denote old and new respectively

This formulation allows the total travel market to expand or contract in line with the size of the 'not travel' transit direct demand elasticity.

5. MARKET SEGMENTATION

Both binary and MNL models assume that common parameter values apply to all respondents in the estimation data set(s).

- o This strong assumption may be relaxed by market segmentation: parameters may be estimated for different market segments.

- o Taken to the limit, markets may be segmented until they each comprise a single individual; the difference in individual parameter values then resulting from 'random taste variation'.

  - Unfortunately, the number of replications (8) is insufficient for individual parameters to be produced reliably (the confidence interval surrounding the mean estimate being very wide).

Market segmentation may be accommodated in estimation by:

(i) carrying out separate estimations controlled for individual or grouped characteristics producing, for example, separate models for males and females;

(ii) Incorporating into the basic model additional 'interaction' terms through which sex, for example, can be assessed through its (additive or subtractive) effect on the main variable parameters.

  - Characteristics are incorporated by specifying them as dummy variables (0,1), multiplying the dummy variable with the main variables and including the resultant 'interaction' variables into the basic model.

  - The inclusion of sex into the linear strength of preference model is shown below:-

$$STP := B_o + \sum B_i \cdot X_i + \sum B_{i} \cdot{,SEX} \left[X_i \cdot SEX \right] \qquad \text{(B12)}$$

Where:

Sex = 0 if male
1 if female

Each approach has its own merit:

- o Approach (i) has theoretical advantages since it imposes weaker restrictions on the error structure.
- o Approach (ii) allows the slope parameters to vary but restricts the error variance to be the same in the different market segments.

Approach (ii) does have the major practical advantage however of selecting characteristics during estimation whereas, approach (i) requires tests of significance to be performed after estimation.

- o It was decided to adopt approach (i) Section III listed the market segmentations performed.
- o Testing the difference between parameter estimates used the "difference between two means t test" shown below:

$$t_i := \frac{B_1 - B_2}{\left[SE_1 + SE_2\right]^n} \qquad n := \frac{1}{2} \qquad \text{(B13)}$$

6. PARAMETER TESTS OF REASONABLENESS

In this section a more formal presentation of the three tests of reasonableness discussed in section III is provided.

(1) Elasticities of Demand

The elasticities of demand provided by the SP models are mode (or travel alternative) share elasticities.

For the logit model form, elasticities are;

$$Exi = Bi\ Xi\ (1-Pi) \qquad \text{(B14)}$$

where Exi = elasticity of mode i with respect to variable x

The derivation is set out below

$$Exi := B_i \cdot X_i \cdot \left[1 - P_i\right]$$

$$Ex_i := B_i X_i$$

Where Ex_i := Elasticity of mode i with respect to variable x

The derivation is set out below:

$$\delta \cdot \log \frac{P_i}{1 - P_i} := \beta \, \delta \cdot X_i \qquad [B15]$$

$$\delta \cdot \log \left[\approx \delta \cdot \frac{n}{n}, \log \cdot \left[\frac{x}{y} \right] := \log \cdot x - \log \cdot y \right.$$

Therefore:

$$\delta \; \log \left[\frac{P_i}{1 - P_i} \right] \approx \left[\frac{1}{P_i} + \frac{1}{1 - P_i} \right] \delta \cdot P_i := \frac{1}{P_i \cdot \left[1 - P_i \right]} \cdot \delta \cdot P_i \qquad [B16]$$

Therefore:

$$\delta \cdot P_i := P_i \cdot \left[1 - P_i \right] \cdot \beta \cdot \delta \cdot X_i \qquad [B17]$$

$$\varepsilon \approx \frac{\delta \cdot P_i}{\delta \cdot X_i} \cdot \frac{X_i}{P_i} := P_i \cdot \left[1 - P_i \right] \cdot \beta \cdot \delta \cdot X_i \cdot \frac{1}{\delta \cdot X_i} \cdot \frac{X_i}{P_i} \approx \beta_i \cdot \left[1 - P_i \right] \cdot X_i \qquad [B18]$$

- The elasticity of demand depends on

  1) Value of Bi

  2) Base probability of using mode Pi

  3) The base factor level.

- The relationship of elasticity and B is positive (as B increases, the elasticity of demand increases).

- The relationship with the base probability is negative: the higher the share the lower the elasticity.

- The relationship with factor level is positive.

There are a number of different measures of elasticity for logit models:

(1) Representative elasticity (RE)

$$RE = B(1-P)X \qquad (B19)$$

where mean values for P and X are inserted

(2) Aggregate point elasticity (APE)

$$APE = \left[\frac{\Sigma P_i \left[1 - P_i\right] BX}{\Sigma P_i}\right] \qquad (B20)$$

For which, if the change in X is uniform across individuals the aggregate point elasticity becomes a weighted average of the individual elasticities.

Of the two measures, the representative elasticity is the easiest to calculate since it ignores the distribution of individual elasticities.

- The measure can therefore be biased if the group is heterogeneous and of an asymetric distribution.

In this study, APE measures are presented and comparisons made between the three disaggregate estimation techniques.

- The linear strength of preference measure cannot be used directly to provide elasticities.
  - The dependent variable needs to be scaled to the 0,1 interval.
- If a logit model form is adopted with end points greater than 0 and less than 1 as in the Log Odds Analysis (.1 and .9 respectively) a strength adjustment factor may be developed.

Given that both the STP and LO functions are linearisable, the adjustment factor is simply the ratio of the two slopes of the linearised lines.

- With the 0.1 to 0.9 LO scale, the adjustment factor is 1.1. This is proved below:

  When STP = 5 : STP-3=2 : P=.9 : ln (P/1-P) = 2.197
  STP = 1 : STP-3=-2 : P=.1: Ln (P/1-P) = -2.197
  Ratio of slopes = (2 - - 2)/(2.197 - - 2.197) = 0.91

Therefore to convert the STP to the LO probability scale the STP parameter needs to be multiplied by the reciprocal of 0.91 ie approximately 1.1.

- It is not recommended that these elasticities of demand be used in forecasting the effects of CTA fare structure changes. This is simply because the elasticity measure is non constant depending on the base mode share and fare.
- The 'Incremental Logit Model' should be used to instead. It is a simple reformulation of the logit model.

$$P_i^1 := \frac{P_i \cdot e^{\delta Ui}}{\sum_j P_j \cdot e^{\delta Uj}} \qquad (B21)$$

Where:

P_i^1 := New mode share

- The Incremental Logit Model requires data on:
  - Zonal transit trips
  - Car trips
  - Base and forecast transit fare

(2) Values of Time

The value of time may be defined as the rate at which individuals trade off time against money keeping utility constant.

- For the AC survey, deriving mean valuations of time from the estimated model is relatively straightforward since all factors are expressed in terms of a single journey.
  - Mean valuations are simply the ratio of the selected time factor parameter (eg walk time) over the transit fare parameter multiplied by 60 to express the value of time in cents per hour.
- For the PW survey, factors require standardization. Factors were standardized by expressing all costs in cents per one way trip and times in minutes per one way trip.

[B22]

$$\mathrm{VoT}\ (\text{transit fare}) := \frac{\beta \cdot \text{travel time difference}}{\beta \cdot \text{fare per month}} \cdot \frac{60}{\text{one way trips per month}}$$

- The value of time presented in Section IV were based on 40 one way trips per month.

Assumptions need to be made regarding the gasoline consumption and average distance traveled per single trip to determine the value of time expressed in terms of gasoline price.

- Fuel consumption was assumed to be 20 mpg and an average distance of 7 miles was adopted.

The confidence interval surrounding the mean value of time (or valuation of time components) is that for nay ratio estimate as shown below:

$$\frac{Bx}{By} \approx tc \left[\left[\frac{Bx}{By}\right]^2 \cdot \left[\frac{Var(x)}{Bx^2} + \frac{Var(y)}{By^2} - 2\,\frac{Cov(x,y)}{BxBy}\right] \right]^n \qquad n := \frac{1}{2} \qquad [B23]$$

where Var = Variance
Cov = Covariance
tc = critical 't' value at selected confidence level

o The variance of the estimates can be calculated from the parameter estimates and 't' values presented:

$$Var := \left[\frac{B}{t}\right]^2 \qquad [B24]$$

Where:

Pt := Probability of using transit

$U := B_o + \Sigma \cdot B_i \cdot X_{ij}$

B_i := SP estimated parameters

X_i := Perceived level of factor i

A_o, A_i := Validation parameters

The critical value for t at 95% confidence with over 100 observation is approximately two.

- o The confidence interval equation (B23) simplifies by virtue of the orthogonal matrices which should produce zero covariance between estimates.

- o Any covariance shown in the estimation data bases is attributable to some respondents failing to complete all eight SP experiments.

Testing the difference between the market segments mean values eg males versus females involves a difference of two means 't' test as outlined earlier.

- o Estimating the difference in valuation of two monetary factors eg car park charge and transit fare is done on a similar basis.

- o The time parameter is replaced by the car park charge parameter.

(3) Validation of Stated Preference Parameters

Binary validation was performed.

- o Utility functions derived from the SP parameters together with data on the perceived levels of factors were used to predict the travel mode respondents would use (for the intercepted trip). The predicted mode used was then compared with the actual travel mode.

The following functions were estimated by Maximum likelihood estimation:

$$Pt := \frac{1}{1 + e^{A_o + A_i (U)}} \qquad \text{(B25)}$$

- o If the SP parameters correspond reasonably with actual mode choice Ao and A1 will be significantly different from zero and one respectively.
- o If Ao and A1 are significantly different from zero and one respectively, the SP derived parameters can be adjusted accordingly.

Only binary validation models were performed. This was despite the ACS providing data to enable multinomial validation to be attempted. The added complexity was not considered to warrant any improvement in validation information in the absence of surveys conducted on the 'not traveling' validation was performed only on the transit-car and transit-walk data sets.

7. ANALYSIS OF SECOND BEST ALTERNATIVE

Maximum likelihood estimation was used to determine the important factors underlying transit users stated second best alternative (SBA) in the AC survey.

- o A trinominal model was estimated.

The SBAs modeled were:

- Car
- Walk
- Not travel

The variables used to explain the variation in response were:

- Car Availability
- Socio-economic
  - Age,
  - Sex,
  - Income,
  - Race
- Trip characteristics
  - Distance destination
  - CBD/non CBD

8. ANALYSIS OF NEVER TRAVEL BY CTA

A binary model of response to the question of usage of CTA in the AC survey was estimated by Maximum Likelihood Estimation.

- o Variables similar to those in the SBA analysis were used to explain response.

5/11/80